Genito-Urinary Imaging

Compiled by;

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Urinary System

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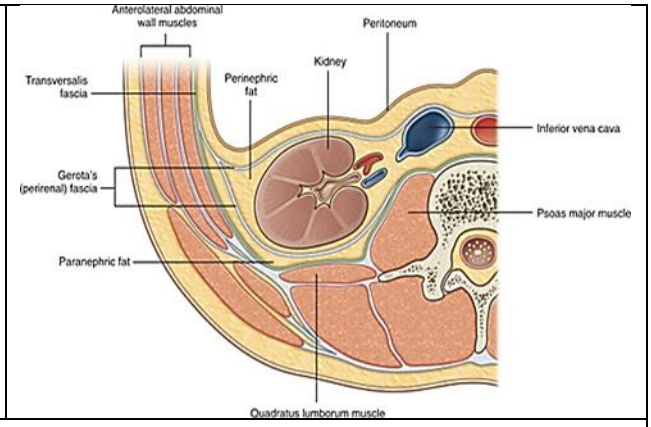
Urinary System

Kidney

Renal Anatomy

- **Site:** Retroperitoneal
  - T12 to L3
- **Size:**
  - Length = 10-15 cm
  - Width = 3-5 cm
  - Thickness
  - Weigh= 150-260 g



- **Shape:** bean shaped:
  - Concave side facing medially = Renal hilum
  - Convex side facing laterally

Arterial Supply:

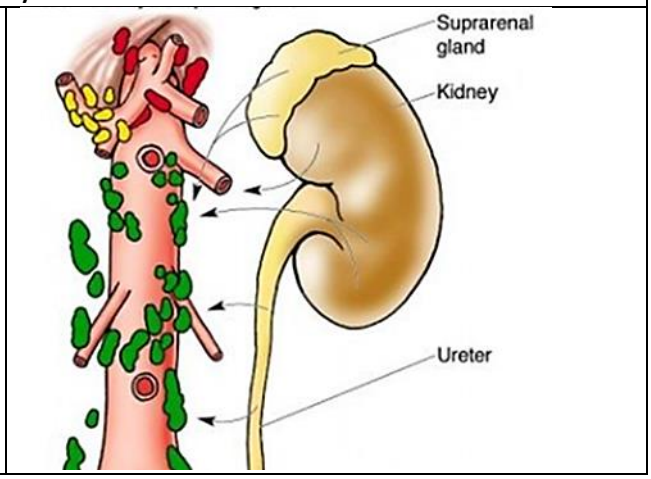
- Renal Artery <= Aorta L2

Venous Drainage:

- Renal Vein = > IVC

Lymphatic Drainage:

- Paraaortic LNs
- Celiac LNs
- Hepatic LNs



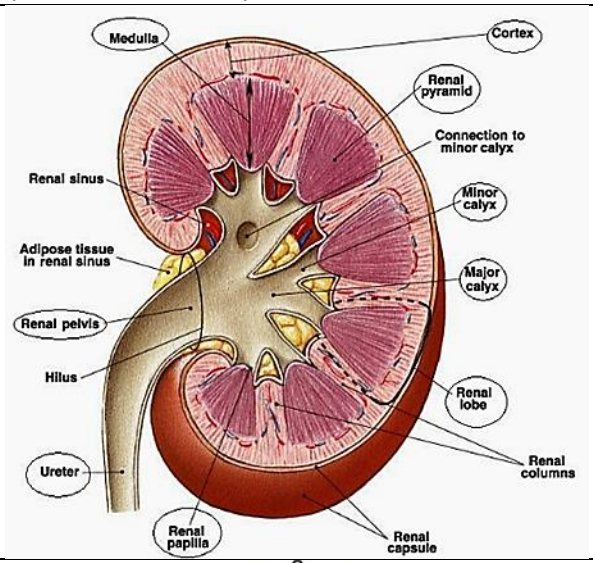
Histological Anatomy:

Renal Capsule:

- Surrounded by perirenal fat
- Surrounded by renal fascia (Gerota's fascia)

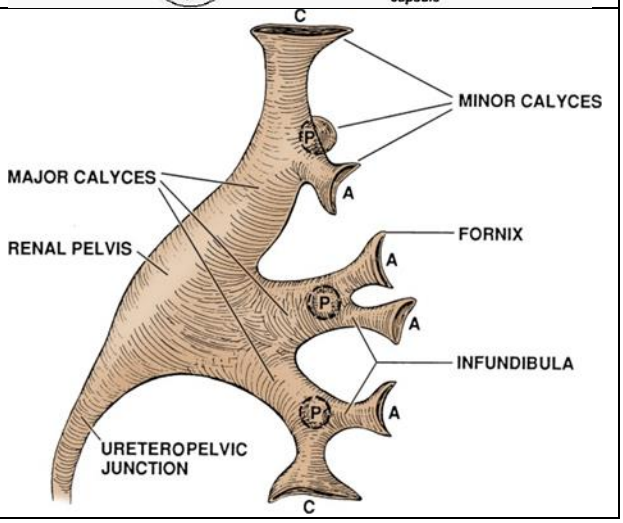
Renal Parenchyma

- Renal Cortex
- Renal Medulla
  - 10-14 Medullary pyramids
  - Papilla is tip of renal medullary pyramid
  - Separated from each other by renal cortex / column
- Renal lobe = Cortex + Medulla



Renal Sinus

- Fat filled compartment communicating with perinephric fat space
- Pelvicalyceal system:
  - 7-11 Minor calyx
  - Infundibulum
  - 2-3 Major calyx
  - Renal pelvis
  - Renal arteries, veins, nerves and lymphatics



Imaging Modalities

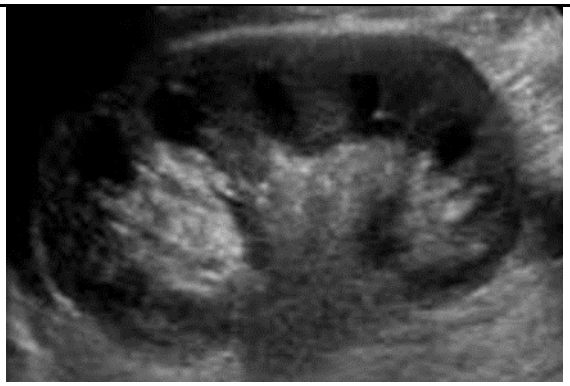
A- US

Scanning Technique:

- Patient position: Supine or lateral decubitus
- Approach: Mid-axillary, subcostal or lower intercostal approach
- 3.5-5 MHz probe

Normal US imaging findings:

- Cortex is less echogenic than liver
- Cortex is more echogenic than medulla
- Pyramids (if seen) are slightly less echogenic than cortex
- Renal sinus (fat and pelvicalyceal system) is more echogenic than cortex
- Renal pelvis may appear as a central slit of anechoic fluid at the hilum



B- PUT

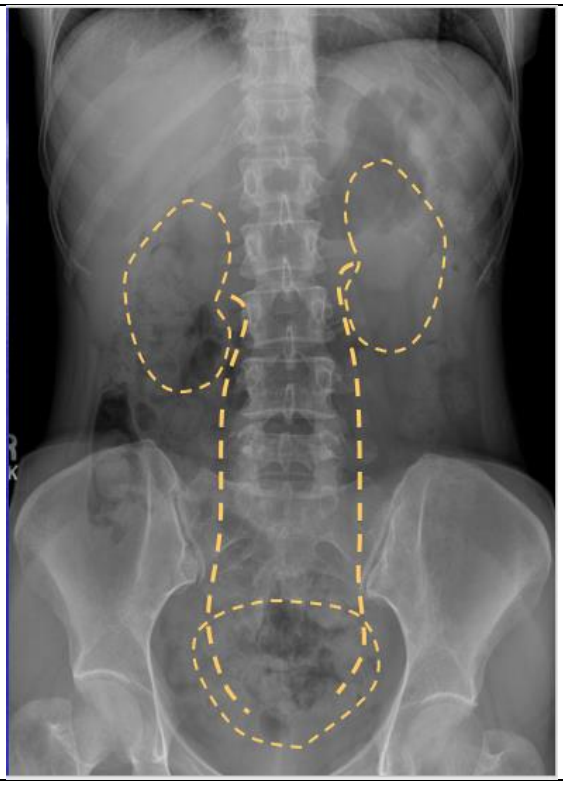
- Should extend
  - from upper renal poles
  - to below the inferior margin of pubic symphysis
- Detection of:
  - Renal Calcifications
  - Urinary tract stones

C- IVU

- Visualization of urinary system resulting from IV injection of contrast

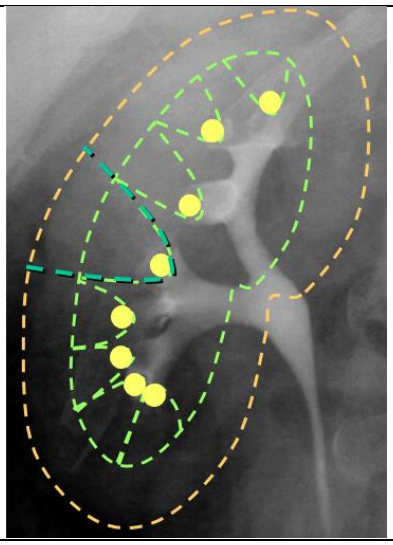
1) Scout film

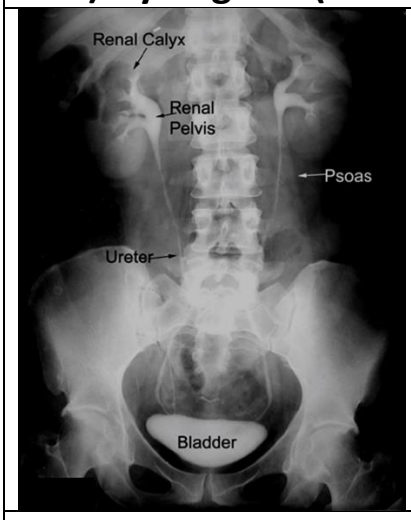
When to look for Stones?



2) Nephrogram (5min)

- Renal parenchyma = cortex + Medulla
- Renal pelvicalyceal system:
  - Minor calyx
  - Calyceal cupping by papillae
  - Infundibulum
  - Major calyx
  - Renal pelvis



3) Pyelogram (10min)	4) Compression
	
5) Cystogram	**6) Post Voiding**

D- CTUT

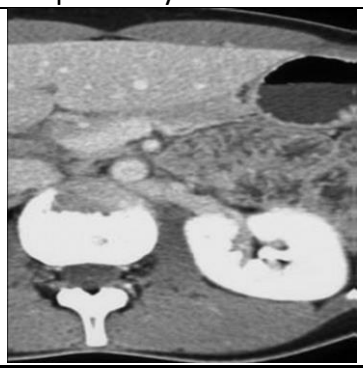
→ Stones => Noncontrast CT

→ Postoperative complication (Urine extravasation) => Excretory phase

→ Tumors => Multiphasic

→ Urethera => Voiding urethrogram.

❖Triple Phase Protocol:

Precontrast phase Abdomen and pelvis	**Nephrographic Phase (NP) Abdomen:**	**Excretory phase (EP) Abdomen and Pelvis:**
• Calcification • Stones • Base line for density measurement	• 100 sec after contrast injection. • Homogeneous enhancement of renal parenchyma. • Best phase for detection of subtle parenchymal lesions	• 5 min after contrast injection. • Opacification of urinary system • Renal pelvis – Ureteric – UB anomalies or pathologies.
		

❖Split-bolus" Protocol:

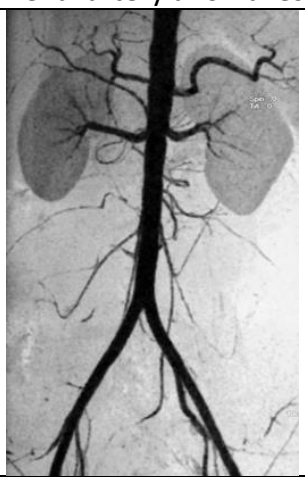
- Unenhanced CT scan
- A fractionated dose of contrast material:
  - 1st dose: (30–50 mL) contrast material
  - 2nd dose: (80–100 mL) contrast material 8–10 min after 1st dose
- A subsequent scan, obtained 100 seconds after the second dose of contrast material, contains excretory information from the first dose and nephrographic information from the second dose.
- Reduce the total number of scans from three to two scans
- Decrease radiation exposure

❖5 Phases Protocol

- **Non-contrast phase**
- **Arterial phase = 15-25 sec**
- **Corticomedullary phase (CMP) = Late arterial phase = 35-70 sec**
- **Nephrographic Phase (NP) = 100 sec**
- **Excretory phase (EP) = 3-5 min**

Early Arterial Phase => Coronal MIP

- 15–25 s after IV contrast injection
- Opacification of renal arteries.
- Renal artery pathology
- Renal artery anomalies

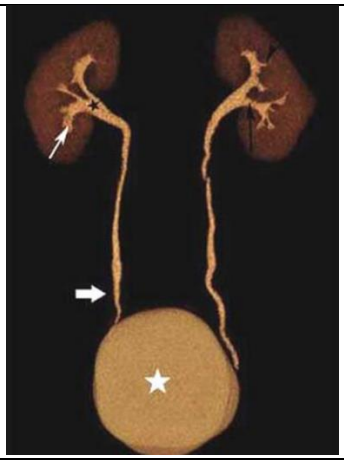


Corticomedullary phase (CMP):

- 35–70 s after IV contrast injection.
- Enhancement of the renal cortex.
- Maximum opacification of the renal veins.

Excretory Phase (EP) => Coronal MIP:

Excretory Phase (EP) => Coronal VR:



E- MRI

Conventional MRI:

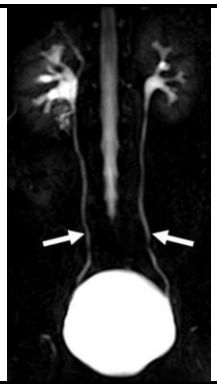
- Axial T1 GRE T1 in-of-phase
- Axial T1 GRE T1 out-of-phase
- Axial T2 SSFSE
- Axial T2 FS
- Coronal T2 SSFSE
- Axial DWI
- Axial ADC

MRU:

1) Static-Fluid MR Urography

Coronal T2-Thick Slab:

- HASTE = half-Fourier acquisition single-shot turbo spin echo
- RARE = rapid acquisition with relaxation enhancement
- Half-Fourier rapid acquisition with relaxation enhancement
- SSFSE= Single-shot fast spin-echo
- SSTSE = Single-shot turbo spin-echo.



2) Excretory MR Urography

- Excretory phase of enhancement after IV administration of gadolinium-based contrast material

3D fat-suppressed T1 gradient-echo sequence

- VIBE =Volumetric interpolated breathhold examination
- FAME = Fast acquisition with multiphase Efgre 3D
- THRIVE = T1-weighted high-resolution isotropic volume examination)
- LAVA = Liver acquisition with volume acceleration

Non-distended Urinary Tract Preparation:

- Nonpharmacologic interventions:
  - Intravenous hydration
  - Ureteral compression
- Pharmacologic interventions: such as intravenous diuretics.

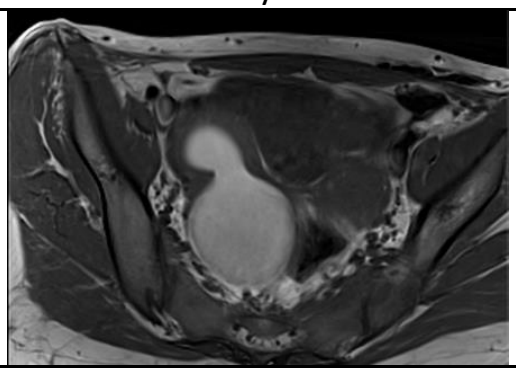
Renal Congenital Anomalies

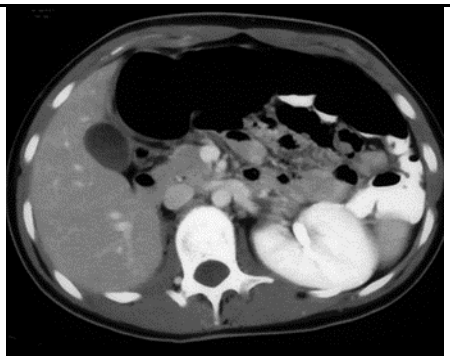
1) Renal Agenesis

- Lt > Rt
- M > F
- Associated with genital anomalies (50%).
- VACTERL = vertebral + anorectal + cardiovascular + tracheoesophageal + renal + limb

Herlyn-Werner-Wunderlich (HWW) Syndrome:

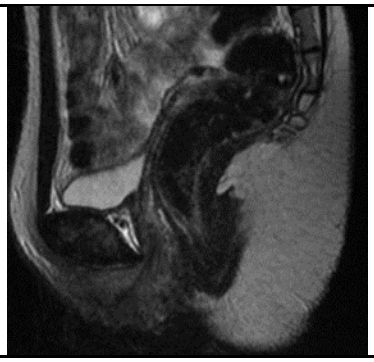
- Müllerian duct anomalies e.g.: Uterus Didelphys
- Unilateral haematocolpos or haematometrocolpos
- Absent kidney on the same side as the uterovaginal obstruction
- Gartner duct cysts

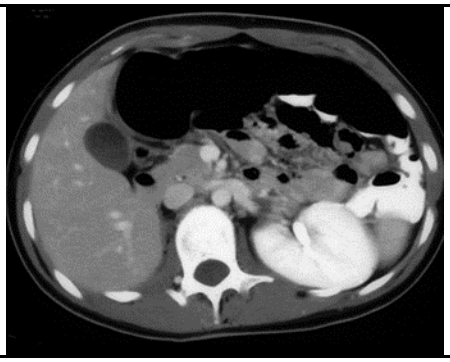




Mayer-Rokitansky-Küster-Hauser Syndrome:

- Congenital absence of the uterus, cervix and upper vagina
- Normal ovaries
- Normal external genitalia
- Associated with renal agenesis





2) Ectopic Kidney

Cranial:

- Thoracic
- Below eventrated diaphragm

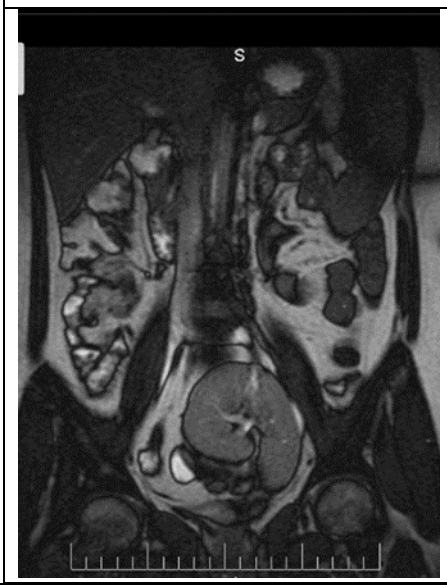
Caudal:

- Abdominal: above iliac crest below L2
- Iliac: opposite iliac crest
- Pelvic: in true pelvis

Crossed:

- Fused
- Nonfused

❖ Pelvic Ectopic Kidney

MRI	PET	CTUT VR
		

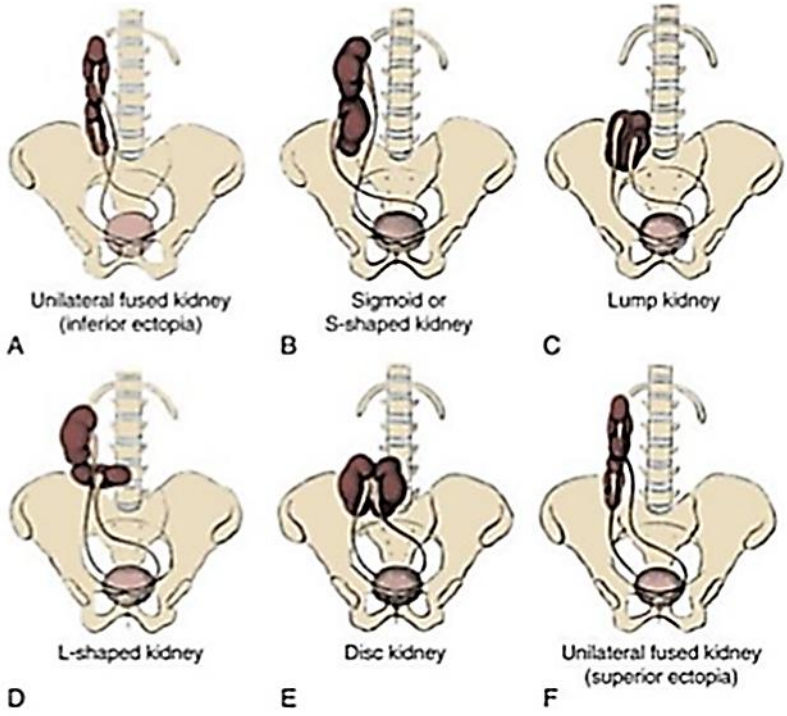
3) Crossed Renal Ectopia

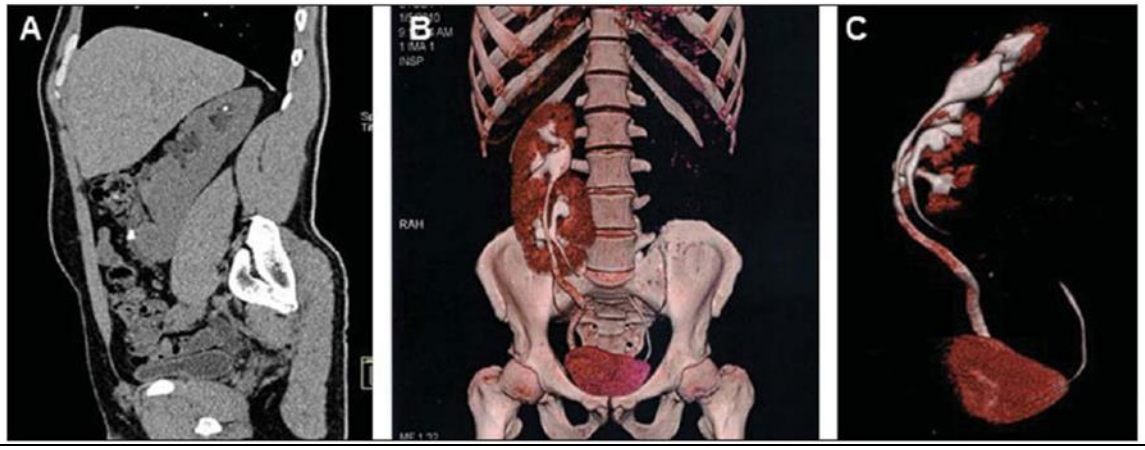
- Located at the opposite side of midline from its uerteric orifice

Types

- Fused (common)
- Non fused

6 forms of crossed fused renal ectopia:



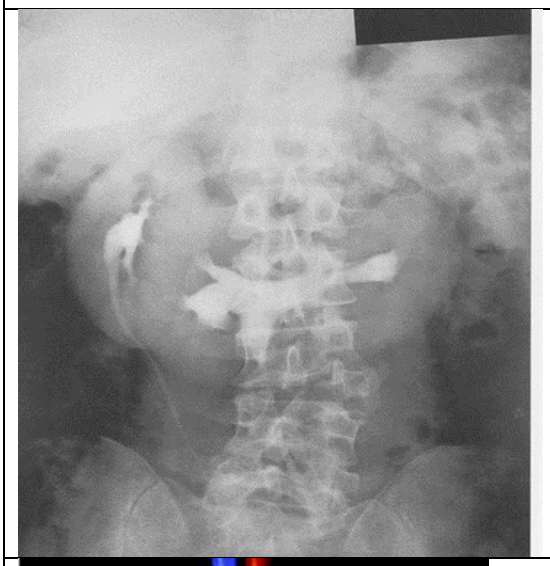
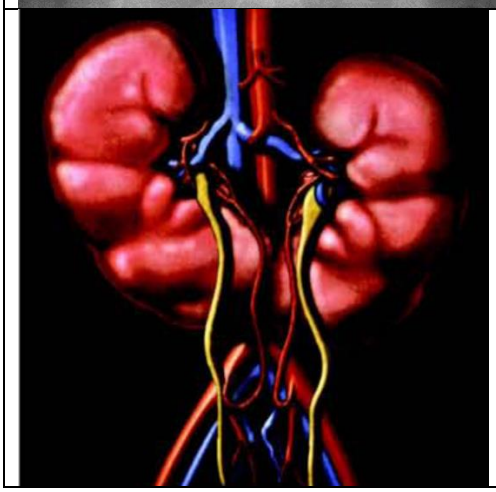


4) Horse-Shoe Kidney

- Abnormal separation:
- Abnormal ascent:
- Abnormal axis: deviated lower poles medially

Complications:

- Trauma: not supported by ribs
- Infections – Stone
- UPJ obstruction.
- Wilms' tumor 2-8 times

L-shaped **Lateral fusion**	**U-shaped** **Midline fusion**
	
	

5) Malrotated Kidney

- Anomalous orientation of the renal hilum.

- Incomplete rotation or nonrotation (most common): hilum faces anteriorly, ureters are located laterally
- Excessive rotation (hyper-rotation): hilum faces posteriorly; renal vessels are located posteriorly
- Reversed rotation: hilum faces laterally, renal vessels are located anteriorly, ureter is located laterally

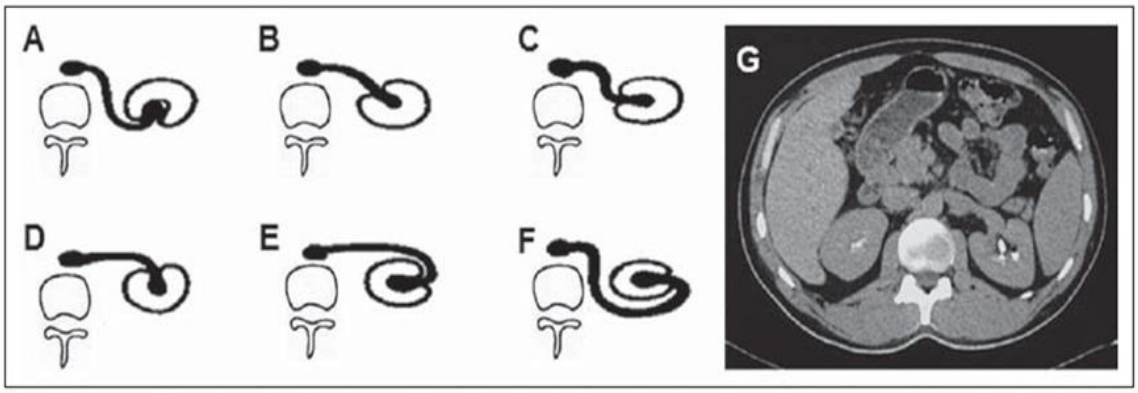


Figure 5. Renal rotation abnormalities. Diagram illustrating a primitive fetal kidney (**A**); normal kidney in adult individual (**B**); incomplete rotation (**C**); hyper-rotation (**D**); exaggerated hyper rotation (**E**) and reversed rotation (**F**). (Adapted from Prando et al.[5]). Axial MDCT image (**G**) demonstrating renal hyperrotation at left.

6) Duplex Kidney

- Incomplete fusion of upper and lower pole moieties resulting in a variety of complete or incomplete duplications of the collecting system

- **Duplex kidney:** two separate pelvicalyceal systems draining a single renal parenchyma
- Duplex kidney draining into:
  - **Single ureter:** i.e. duplex kidney's duplication pelvicalyceal systems uniting at the pelviureteric junction (PUJ)
  - **Bifid ureter (bifid collecting system):** two ureters fissus before emptying into the bladder
  - **Double ureter (double collecting system):** two ureters that drain separately into the bladder.

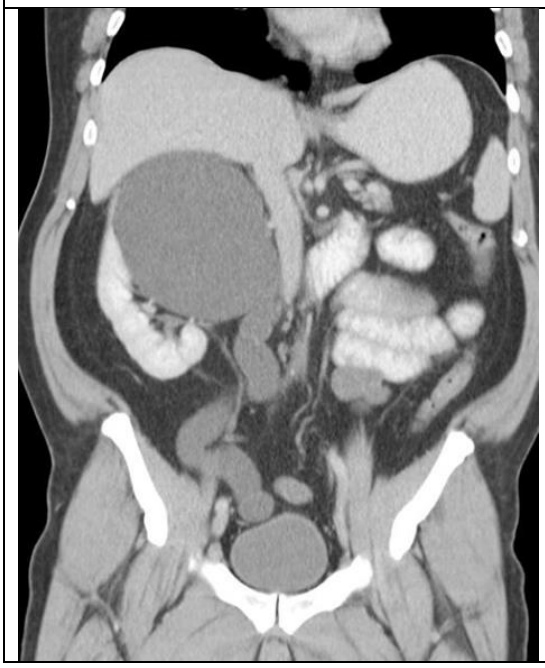
❖ Weigert-Meyer Rule:

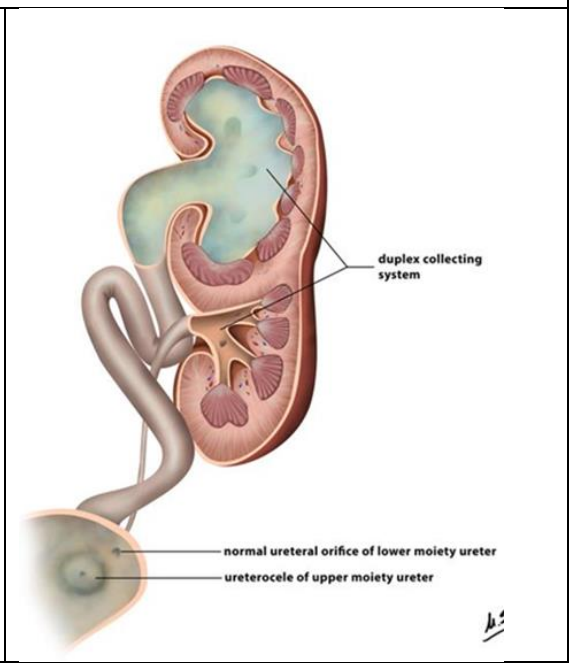
Upper pole moiety:

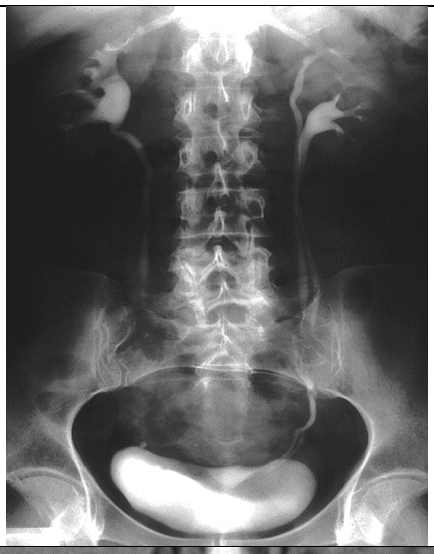
- Ureter inserts heterotopic: medial and caudal to normal ureter
- Ureterocele => Obstruction => Hydroureteronephrosis => Downward and lateral displacement of the functional lower moiety collecting system => appearing radiographically as drooping lily sign

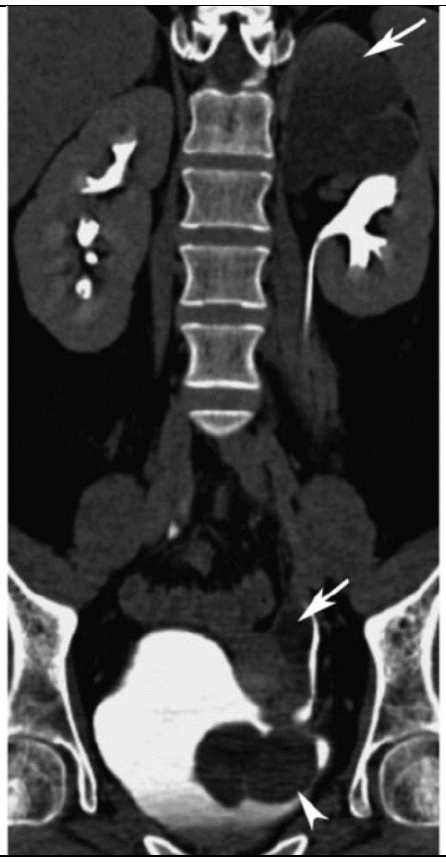
Lower pole moiety:

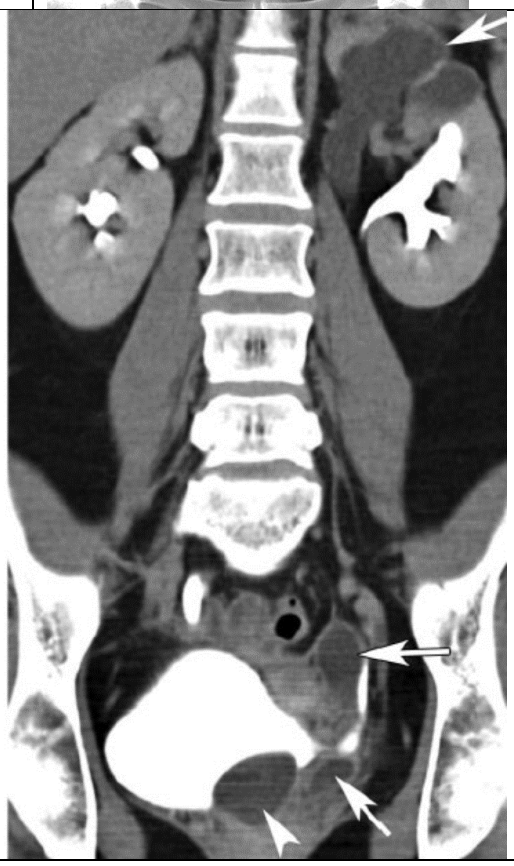
- Ureter inserts orthotropic: Normal ureteric orifice
- Vesicoureteric reflux











7) Uretro-Pelvic Junction Obstruction (UPJO)

- **Most common cause of hydronephrosis in children**

TYPES

Idiopathic: Congenital

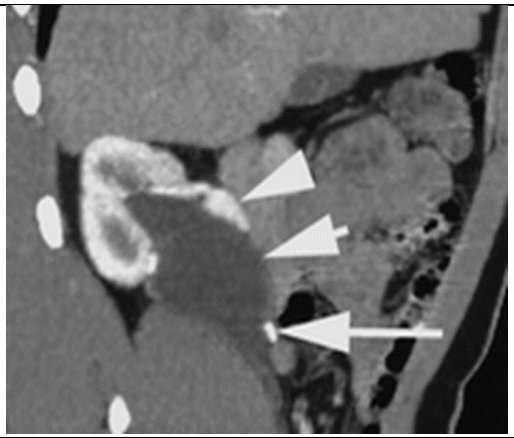
- due to an intrinsic abnormality of collagen or muscle

Secondary UPJO:

- Aberrant vessel
- Iatrogenic causes
- Inflammation
- Tumor are less common

CT Angiography:

- Define vessels prior to endoscopic pyelotomy
- Useful in planning endopyelotomy
- Show relation of pelvis to adjacent vessels



Renal Infections

A- Acute Pyelonephritis

Causative organism:

- Gram negative: E. coli, proteus, klebsiella, Enterobacter

Predisposing factors:

- Vesicoureteral reflux (VUR);
- Obstructive uropathy
- Pregnancy, benign prostatic hypertrophy (BPH)
- Urethral instrumentation
- Diabetes mellitus & other renal pathology

Route of infection:

- Ascending infection (most common)
- Hematogones infection (less common)

Pathophysiology:

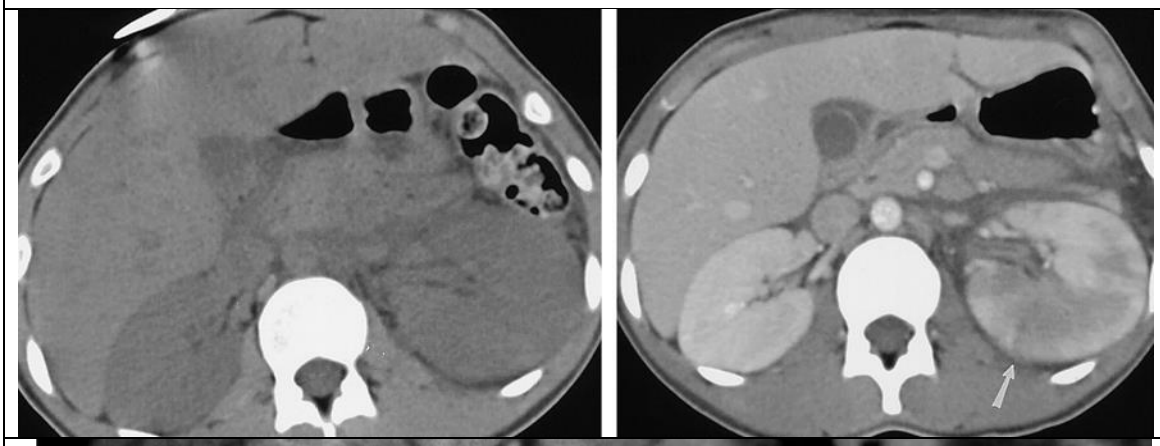
- Urinary tract infection typically originates in the urinary bladder
- Migrates up to the Ureter => up to Pelvicalyceal system
- A tubulointerstitial inflammatory reaction, involving the renal pelvis and parenchyma.

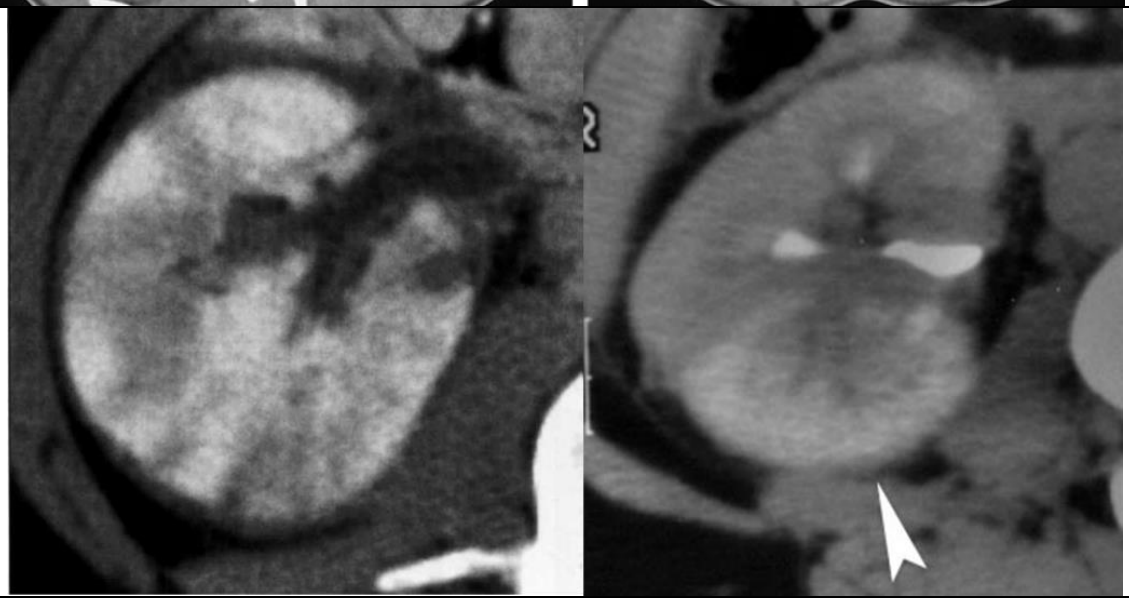
Diagnosis of urinary tract infection is based on:

- **Characteristic clinical features:**
  - An abrupt onset of chills, fever (temperature of 100°F or greater)
  - Unilateral or bilateral flank pain with costovertebral tenderness.
  - Dysuria and urinary frequency and urgency
- **Abnormal laboratory values:**
  - Urine analysis:
    - Pyuria, granular or leukocytic casts
    - Bacteriuria, and a positive urine culture.
  - Blood tests:
    - Leukocytosis with a neutrophilic shift
    - Elevated erythrocyte sedimentation rate (ESR)
    - Elevated C-reactive protein levels (CRP)
    - Occasionally positive blood cultures

Imaging Findings:

- Enlarged Smooth Kidneys
- Striated / Patchy / Persistent / Delayed nephrogram
- Delayed contrast excretion
- Loss of normal corticomedullary differentiation.
- Effacement of the collecting system
- Effacement of the renal sinus fat
- Perinephric stranding.
- Thickening of Gerota fascia



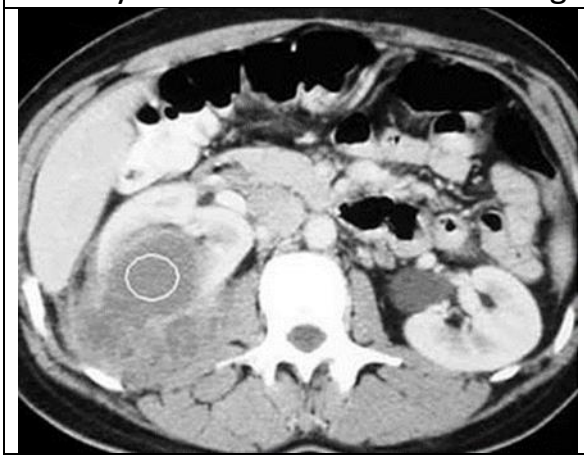


B- Renal Abscess

- A renal abscess should be suspected when appropriate therapy does not lead to clinical response.
- Diabetic patients are predisposed to abscess formation

Imaging Findings:

- Intra- or extra- renal
- A well-defined multilocular cystic lesion
- CT: Low-attenuation
- T1: Low SI
- T2: High SI
- +C: Peripheral / rim enhancement + halo of diminished enhancement may surround the abscess during the nephrographic phase.



C- Chronic Pyelonephritis

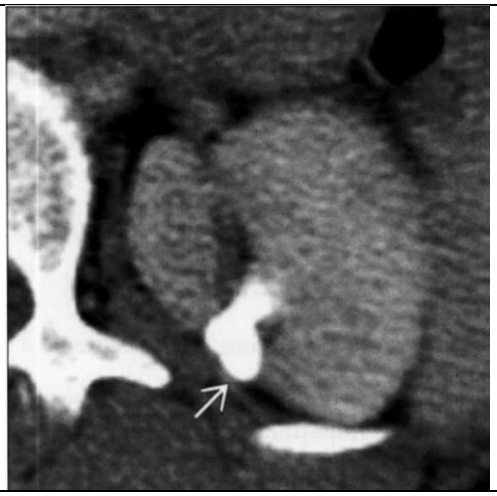
- Longstanding sequelae of recurrent or relapsing renal infection.
- Vesico-ureteric reflux => Intra-renal reflux of infected urine => Tubulo-interstitial inflammation => Renal damage (Reflux nephropathy)

Site:

- Polar regions, due to presence of compound calyces which permit intrarenal reflux of urine

Imaging findings:

- Renal scarring, parenchymal atrophy and cortical thinning
- Hypertrophy of residual normal tissue (which may mimic a mass lesion)
- Caliceal clubbing secondary to retraction of the papilla from overlying scar
- Thickening and dilatation of the caliceal system
- Overall renal asymmetry

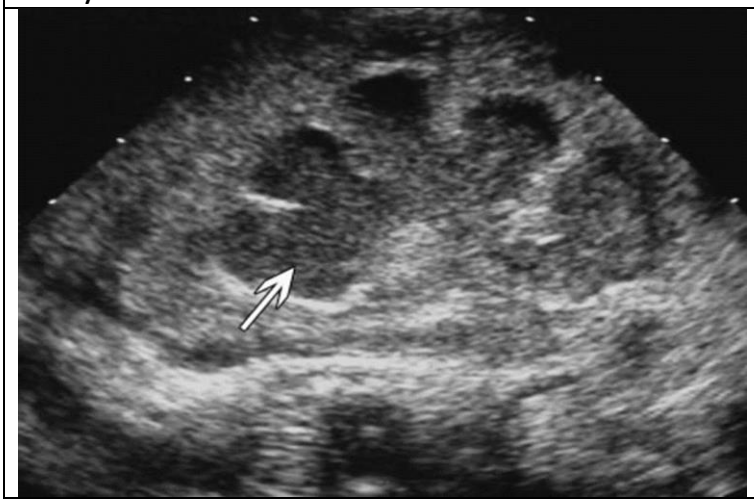


D- Pyonephrosis

- Is infected and obstructed collecting system.
- The obstruction may arise from a variety of disease processes such as:
    - Calculi
    - Tumor
    - Sloughed papilla
    - Strictures.

Imaging findings:

- Dilatation of the pelvicaliceal system.
- Thickening of the renal pelvic wall (2 mm)
- Echogenic collecting system debris.
- Fluid-fluid levels within the collecting system.
- US: Dirty echoes of collecting system
- CT: Fluid of higher attenuation values than usual within collecting system



E- Xanthogranulomatous Pyelonephritis

Imaging findings:

- Diffuse / Focal renal enlargement.
- Non-functioning kidney.
- Destroyed pelvicalyceal system.
- Large Staghorn stone.
- Xantho= Non-enhancing low attenuation (Fatty) tissue
- Granulomatous= peripheral enhancing soft tissue ring.
- Stranding of the perinephric space.
- Thickened Gerota's fascia.
- Extension into psoas muscle and abdominal wall.
- Cutaneous / Enteric fistula.

F- Emphysematous Pyelonephritis

- Emphysematous pyelonephritis is a life-threatening necrotizing infection of the kidneys characterized by gas formation within or surrounding the kidneys.

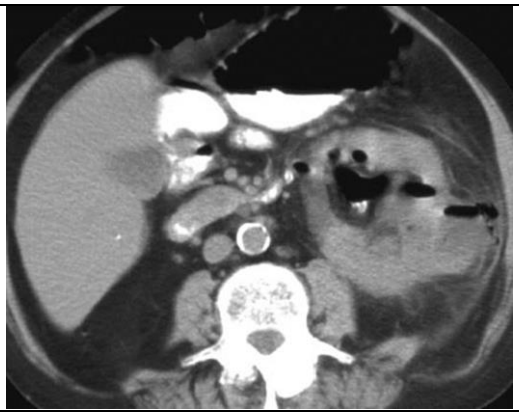
Predisposing Factors:

- The majority (approximately 90%) of patients have poorly controlled DM.
- Immunocompromised
- Urinary tract obstruction secondary to uroliths, neoplasm, or sloughed papilla.

Causative Organism

- The most commonly identified organisms are E coli, Klebsiella pneumonia, and Proteus mirabilis

Imaging findings:

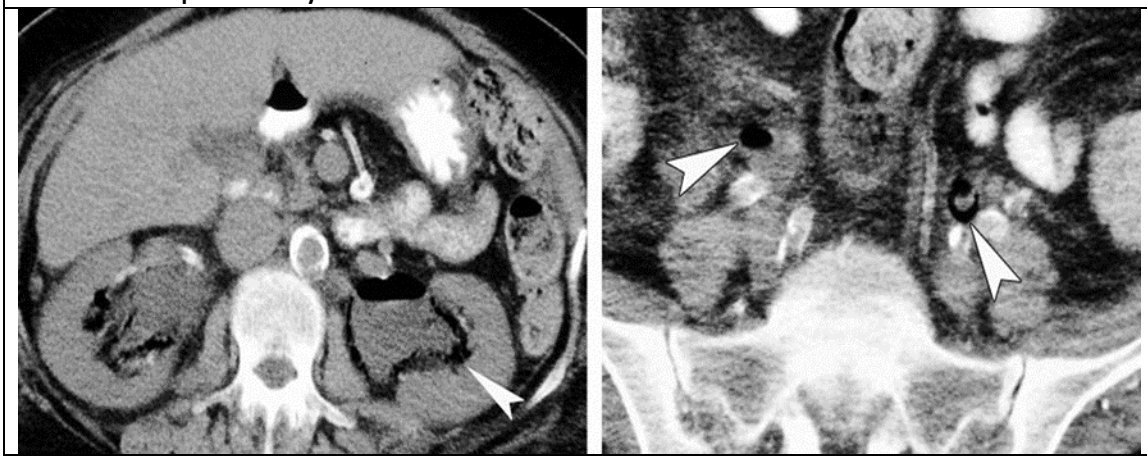
Type 1 emphysematous pyelonephritis is characterized by:	**Type 2 emphysematous pyelonephritis is characterized by:**
• Renal parenchymal destruction • Streaky or mottled areas of gas. • Absent intra- or extrarenal fluid collections • More aggressive clinical course.	• Renal or perirenal fluid collections Bubbly or loculated gas or by gas within the urinary collecting system
	

G- Emphysematous Pyelitis

- Emphysematous pyelitis is a less aggressive form of emphysematous infection of the upper urinary tract.
- Emphysematous pyelitis is diagnosed when gas is localized to the renal collecting system.
- Emphysematous pyelitis is more common in women and is also associated with diabetes and urinary tract obstruction.
- The overall mortality rate is significantly less than that for emphysematous pyelonephritis

Imaging Findings:

- Dilated collecting system.
- Gas bubbles or gas-fluid levels within the renal caliceal system or renal sinus.
- Gas in the outline of the ureters.
- Lack of parenchymal Gas.



H- Renal T.B.

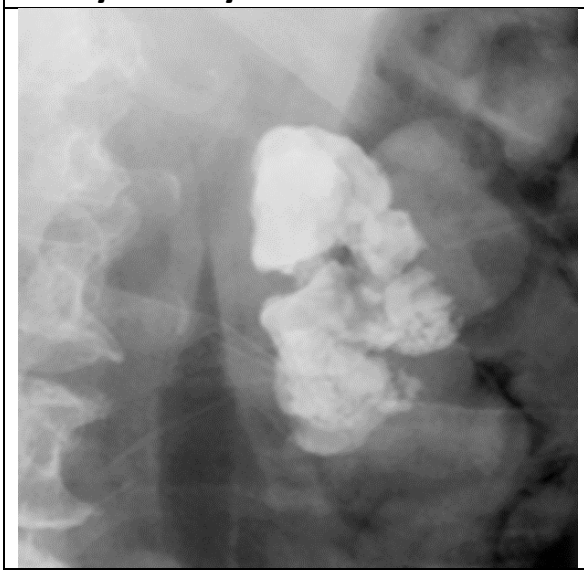
- A subset of genitourinary tuberculosis, accounts for 15-20% of extra-pulmonary tuberculosis

Calcifications:

- Linear streaks.
- Curvilinear.
- Mottled.
- Amorphous.
- Putty kidney

Imaging findings:

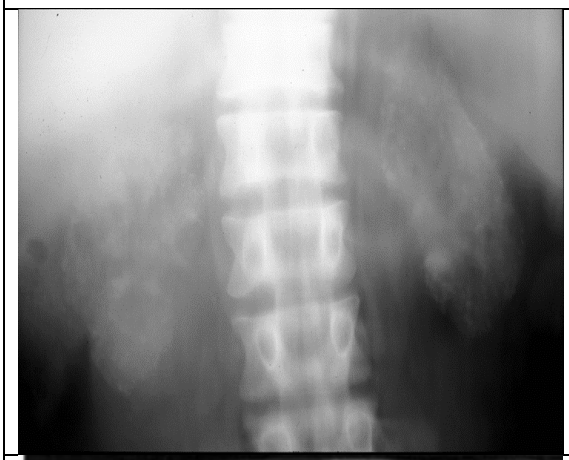
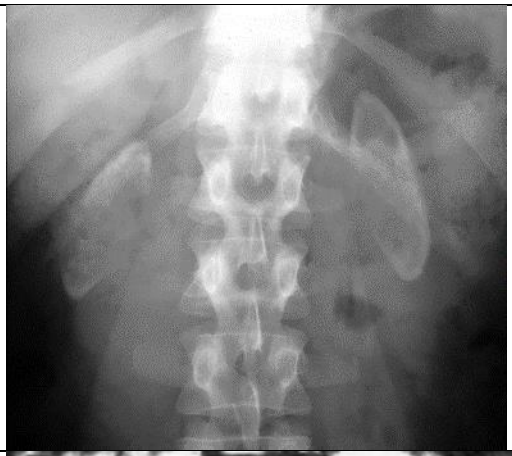
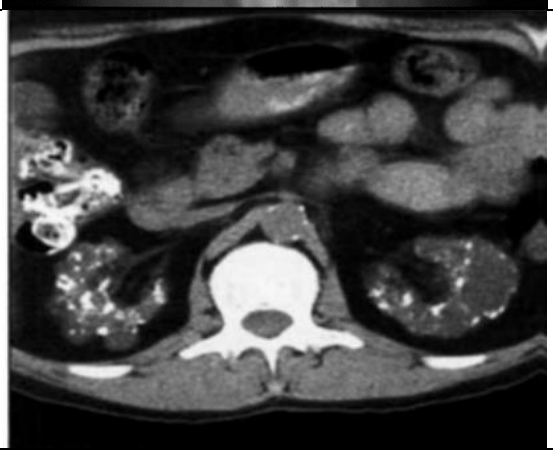
- Parenchymal scarring (as pyelonephritis).
- Papillary necrosis
- Tubercloma cavity.
- Phantom calyx = a calyx which fails to fill with contrast
- Moth eaten calyx = ragged, feathery calyceal outline due to irregular erosions of the calyx
- Infundibular stenosis => Hydrocalycosis.
- Infundibular cut off => Amputated calyx.
- No dilated pelvis.

Putty kidney	Phantom Calyx
	

Moth-eaten Calyx	**Amputated Calyx/Hydrocalycosis**
TB autonephrectomy	

Renal Calcifications

I- NEPHROCALCINOSIS	
A) Cortical Ca (5%):	**B) Medullary Ca (95%):**
1) Acute cortical necrosis 2) Chronic glomerulonephritis. 3) Transplanted kidney as a late complication of chronic rejection.	1) Medullary sponge disease. 2) Papillary necrosis. 3) Renal tubular acidosis. 4) Hyperparathyroidism.

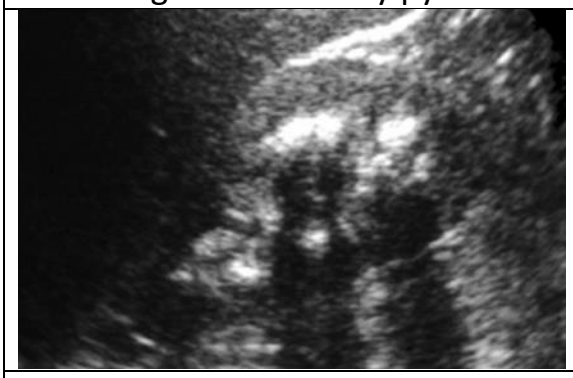
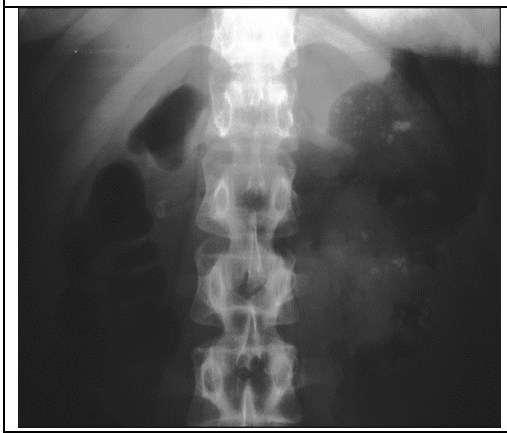
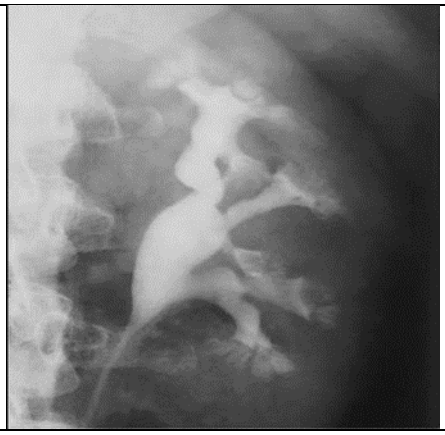
A) Cortical Calcification:	
Diffuse Punctate	**Tram track**
	
	

B) Medullary Calcifications:

1) Medullary Sponge Kidney

- Also known as Lenarduzzi-Cacchi-Ricci disease.
- Medullary sponge kidney is a congenital developmental abnormality characterized by ectasia and cystic dilatation of the intrapyramidal or intrapapillary portions of the renal medullary collecting ducts.

- Age = 3rd to 5th decade of life
- Unilateral or Bilateral
- Segmental or Diffuse

US: Echogenic medullary pyramids	NCCT: Medullary calcification
	
<u>Bouquet of flowers appearance:</u> microcalcification within ectatic collecting ducts	**<u>Paint Bruch appearance:</u>** due to the pooling of contrast material within the dilated medullary collecting ducts
	

2) Renal Papillary Necrosis

Etiology:

- Analgesic nephropathy
- DM
- S-hemoglobinopathy
- UTI & obstruction
- TB kidney
- Renal transplant
- Alcoholics.

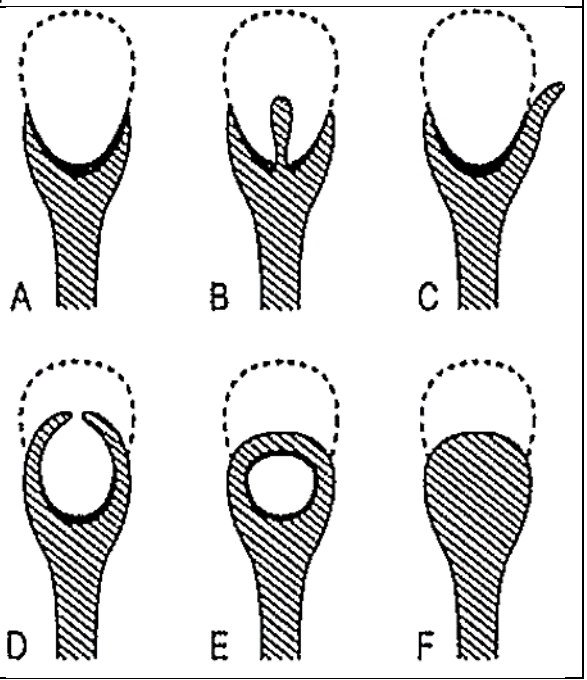
Pathogenesis:

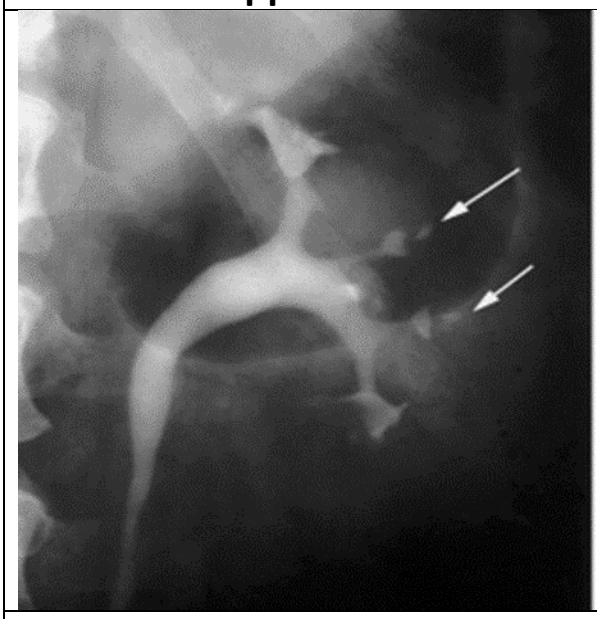
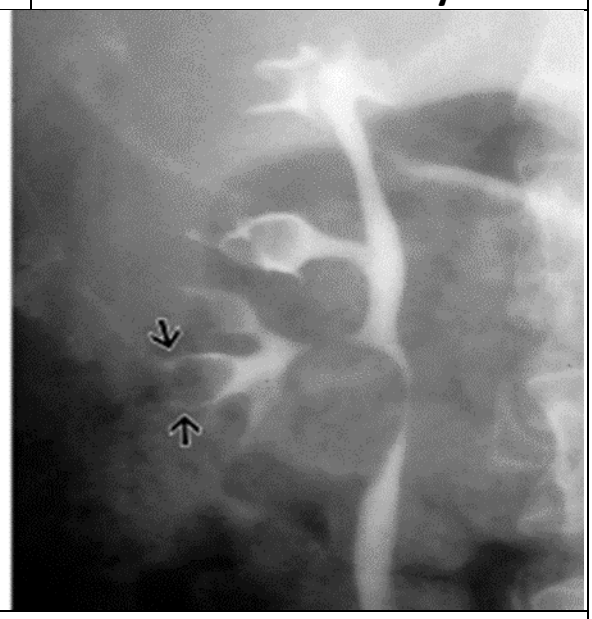
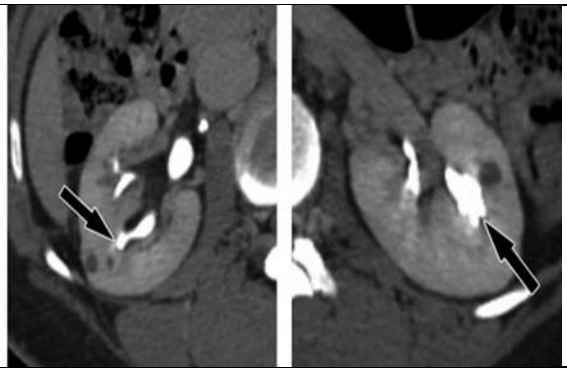
Three types of parenchymal involvement in RPN:

- Medullary type: Necrosis & cavitation at Centre of papillae
- Papillary type: Necrosis & cavitation at periphery of papillae
- Necrosis in situ of papillae ± Ca++ or ossification

Drawing illustrates the different patterns of excavation:

A. Normal
B. Central excavation with ball-on-tee appearance
C. Forniceal excavation
D. Lobster claw appearance
E. Signet ring appearance
F. Sloughed papilla with clubbed calyx.



Ball-on-tee appearance	Lobster claw deformity
	
Clubbed / Blunted / Deformed calyx	
	
Diffuse papillary calcifications	

II- Dystrophic Calcifications

A. <u>TUMORS:</u>

1. RCC 20%
2. WILMS
3. Osteosarcoma of capsule

B. <u>INFECTION:</u>

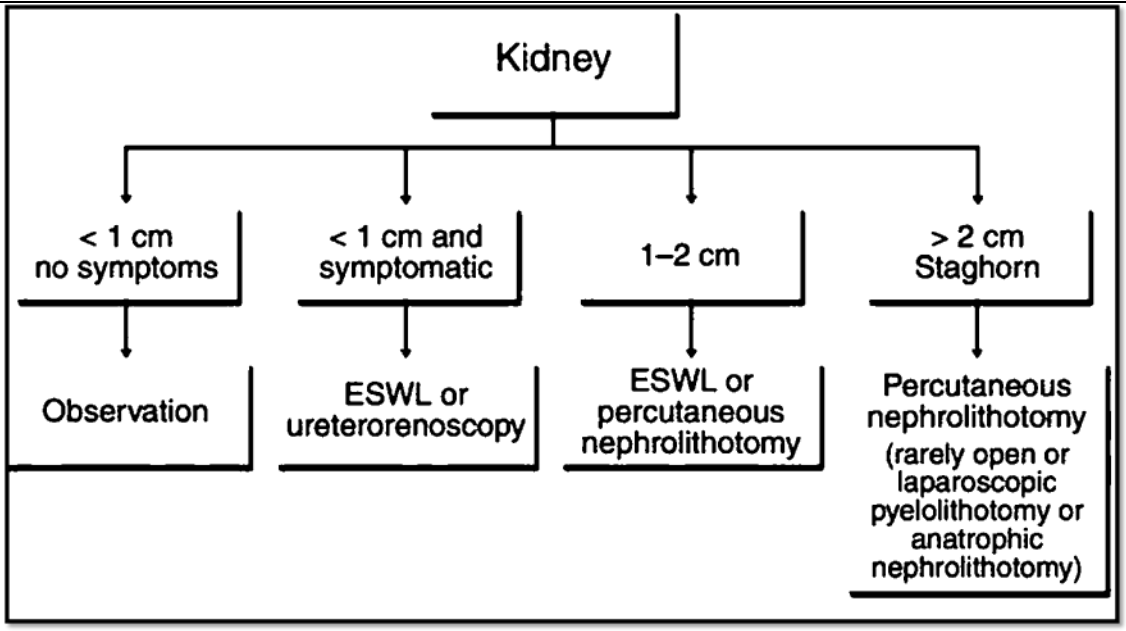
1. T.B
2. Hydatid cyst
3. Simple (egg shell)
4. Milk of Ca++ (Cyst, calyceal diverticulum)

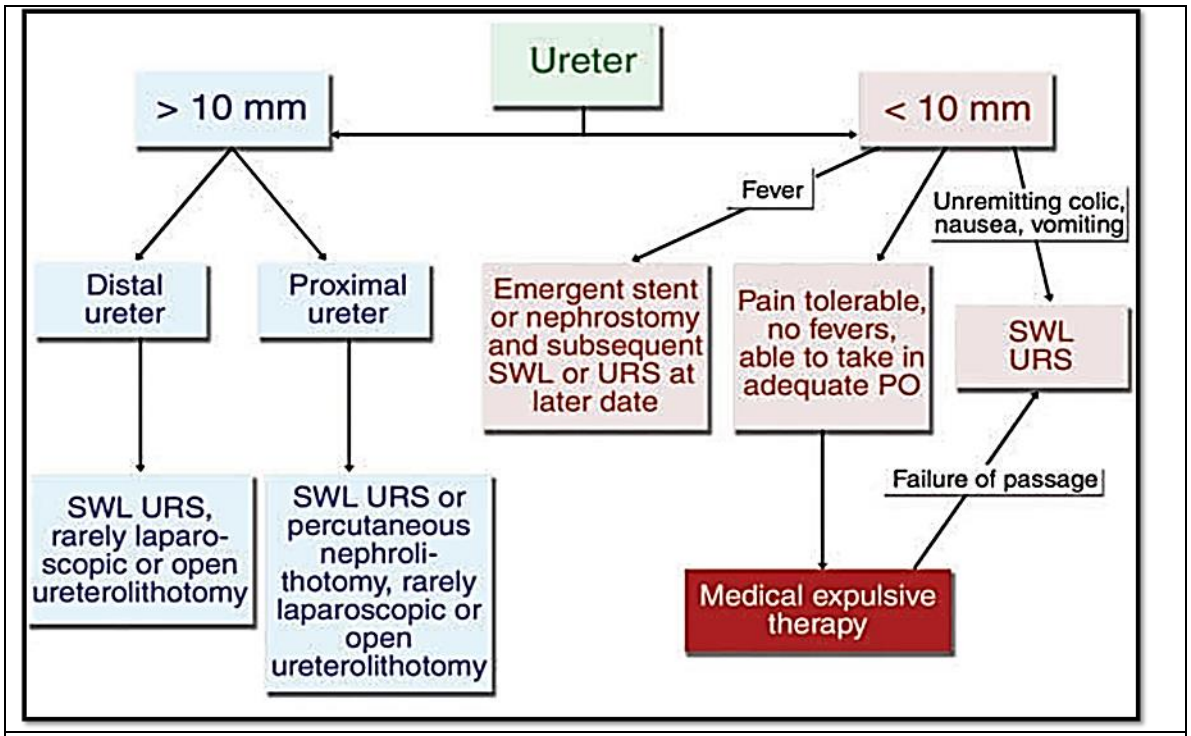
C. <u>Vascular:</u>

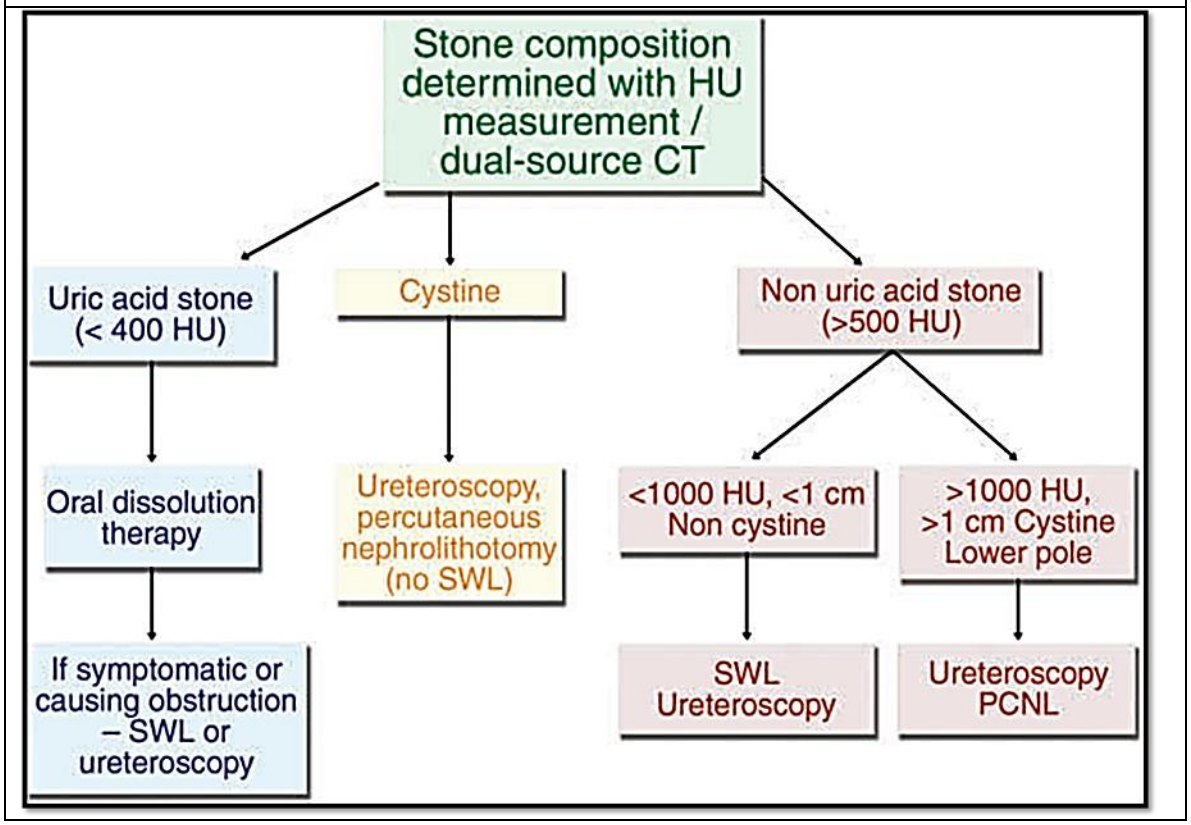
1. Hematoma
2. Aneurysm/AVM

Urolithiasis

	Composition	Frequency of Occurrence	KUB Radiographic Appearance	CT Appearance/Attenuation (HU)	Associated Etiologic Factors
	Calcium oxalate monohydrate and dihydrate (calcium oxalate dihydrate)	40%–60%	Radiopaque	Opacified/ 1700–2800	Underlying metabolic disorder (eg, idiopathic hypercalcuria or hyperoxaluria)
	Hydroxyapatite (calcium phosphate)	20%–60%	Radiopaque	Opacified/ 1200–1600	Usually no metabolic abnormality
	Brushite	2%–4%	Radiopaque	Opacified/ 1700–2800	. . .
	Uric acid	5%–10%	Radiolucent	Opacified/ 200–450	Idiopathic hyperuricemia or hyperuricosuria
	Struvite	5%–15%	Radiopaque	Opacified/ 600–900	Renal infection
	Cystine	1%–2.5%	Mildly opaque	Opacified/ 600–1100	Renal tubular defect




Ureter
> 10 mm
< 10 mm
Fever
Unremitting colic, nausea, vomiting
Distal ureter
Proximal ureter
Emergent stent or nephrostomy and subsequent SWL or URS at later date
Pain tolerable, no fevers, able to take in adequate PO
SWL URS
Failure of passage
SWL URS, rarely laparo-scopic or open ureterolithotomy
SWL URS or percutaneous nephroli-thotomy, rarely laparoscopic or open ureterolithotomy
Medical expulsive therapy


Stone composition determined with HU measurement / dual-source CT
Uric acid stone (< 400 HU)
Cystine
Non uric acid stone (>500 HU)
Oral dissolution therapy
Ureteroscopy, percutaneous nephrolithotomy (no SWL)
<1000 HU, <1 cm Non cystine
>1000 HU, >1 cm Cystine Lower pole
If symptomatic or causing obstruction – SWL or ureteroscopy
SWL Ureteroscopy
Ureteroscopy PCNL

MULTISLICE NON-CONTRAST CT URINARY TRACT

NCCT has become the standard of reference in the detection of urinary calculi owing to its

→ ***High Sensitivity (95%)***

→ ***High Specificity (98%)***

Role of MDCT:

- **Stone diagnosis:**
  - **1ry signs**
  - **2ry signs**
  - **Differential diagnosis**
- **Sone site**
- **Stone burden:**
  - **Stone size**
  - **Stone volume**
- **Stone Fragility (Homogenous or Heterogeneous)**
- **Stone composition / Attenuation**
- **Pre-treatment planning**
- **Post-treatment evaluation**

A- Stone Diagnosis

❖ 1ry signs: a focus of high attenuation

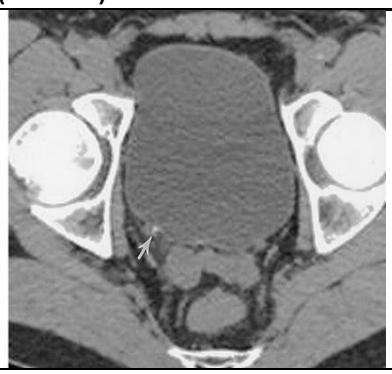
- **All stones are visible at unenhanced CT**, including those that are radiolucent on conventional radiographs, such as uric acid, xanthine, and cystine stones.

The only stones that are difficult to visualize at CT:

- **Indinavir stone** = a protease inhibitor used in the treatment of HIV. This medication can crystallize in the urine and result in stones that may or may not be detected with CT
- **Matrix stones** = aggregates of mucus that may form within the urinary tract of both healthy and immunosuppressed individuals. These matrix stones tend to have soft-tissue attenuation at unenhanced CT unless mixed with calcified impurities.

❖2ry Signs:

1) Hudroureter and hydronephrosis proximal to a stone.
2) Nephromegaly and low renal parenchymal attenuation (more than 5 HU than contralateral side) on NCCT = Pale kidney sign caused by renal parenchymal edema due to obstruction.
3) Perinephric edema consists of stranding in the perinephric fat, perinephric fluid collections, and/ or thickening of the renal fascia.
4) Pyelotubular, pyelolymphatic, pyelosinus, and pyelovenous backflow, and elevated intrarenal venous pressure.
5) Occasionally, excretory phase-enhanced CT scans can document urinary extravasation from caliceal rupture secondary to an obstructing ureteral Stone.

Secondary right hydronephrosis and perinephric stranding	Right ureterovesical junction (arrow)
	
Stone at ureteropelvic junction 2ry signs: Perinephric fluid collection (straight arrow). Gerota's fascia thickened (open arrow).	CT excretory phase: Urinary extravasation into the left perinephric (short straight arrow) and posterior pararenal (curved arrow) spaces

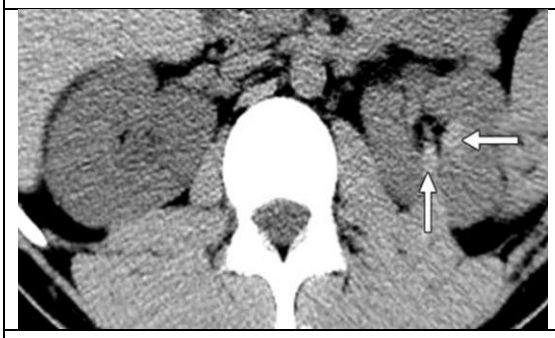
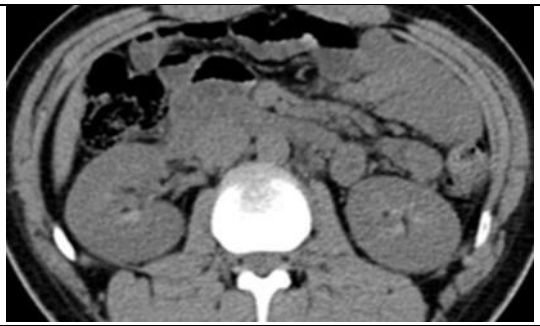
❖ Differential Diagnosis:

<u>Stone VS Extra-urinary abnormalities including:</u>

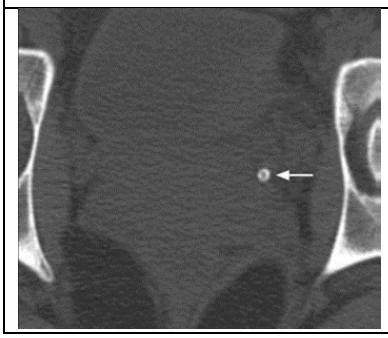
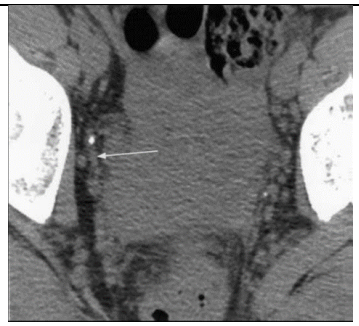
- Appendicitis, diverticulitis, pancreatitis, and gynecologic lesions are often detected at CT in patients with nonspecific abdominal pain mimicking ureteral colic when the diagnosis may not be obvious prior to imaging.

Renal Stone VS Renal Medullary Tip Hyperattenuation?

- Medullary Tip Hyperattenuation reflects increased urinary specific gravity, likely related to high medullary tip NaCl concentrations.

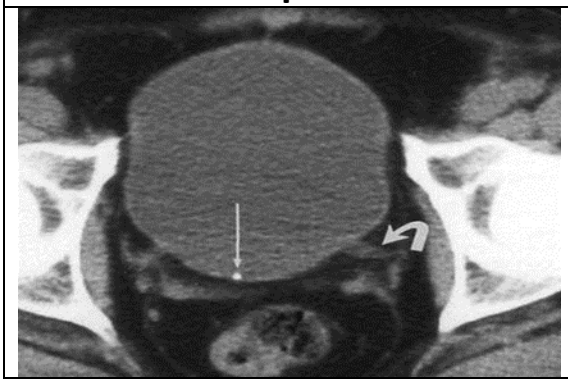
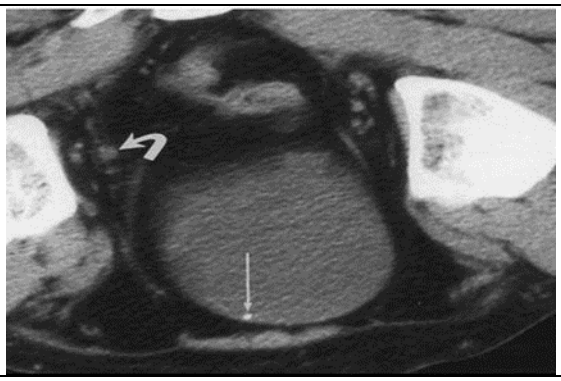
Unilateral renal pyramid high attenuation is subtle secondary sign suggestive of contralateral urinary tract obstruction	Bilateral renal pyramid high attenuation is an occasional incidental normal finding.
	

Ureteric Stone Vs Phlebolith?

Pelvic phlebolith		Stone
<u>Central lucency</u> in the left side of the pelvis	‘‘**<u>Comet-tail’’ sign</u>** eccentric tapering soft tissue extension from one surface of calcification	**<u>Soft tissue rim:</u>** small stone in the ureter surrounded by a halo of soft tissue attenuation.
		

Urinary Bladder Stone Vs Calcification?

- Repeat CT in the prone position confirms this stone is mobile within the bladder (straight arrow)

Supine	Prone
	

B-Stone Burden

Stone Size:

- The greatest linear measurement
- measured to the closest millimeter.
- use bone window settings
- Both 3-D and coronal reformatted images likely allow for more accurate determination of stone size along the z-axis, which is often the longest stone diameter.

Stone volume:

- has been shown to be valuable for preoperative planning
- it is often useful to perform both linear and volumetric measurements of stone burden

C-Stone Fragility:

- Knowledge of the internal structure of stones is another factor that can influence outcome following SWL

- **Heterogeneous stones** are characterized by the presence of internal low-attenuation areas (voids or dark areas) => renders a stone susceptible to fragmentation with treatment
- **Homogeneous stones** have a uniform internal structure => tend to be more rigid and therefore harder to break.

D- Stone Composition:

The attenuation values of urinary calculi at 120 kV:

- **Uric acid = 200–450 HU**
- **Struvite = 600–900 HU**
- **Cystine = 600–1100 HU**
- **Calcium phosphate = 1200–1600 HU**
- **Calcium oxalate monohydrate and Brushite = 1700–2800 HU**

E- Treatment Planning:

MDCT also aids in the presurgical planning of interventional procedures such as PCNL.

F- Post-treatment Evaluation

The purpose of imaging following either urologic intervention or medical therapy is essentially :

- to confirm stone-free status,
- to identify the presence of residual stones,
- to rule out obstruction in the urinary system.
- Detection of complications such as perirenal hematoma and urinoma

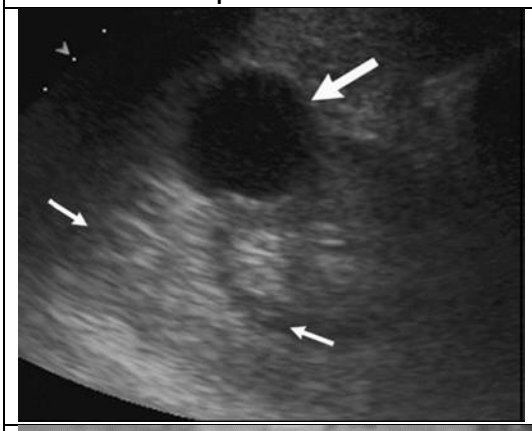
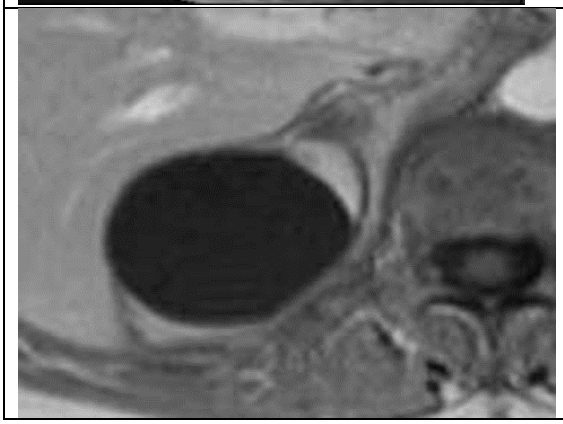
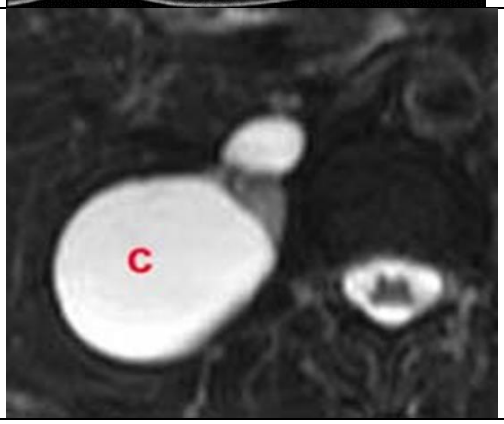
Renal Lesions

→ **Renal Cysts**

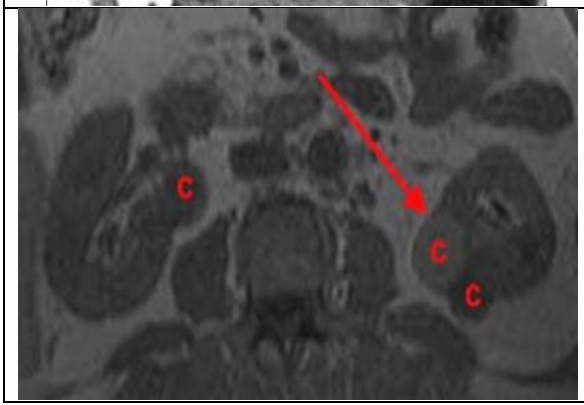
→ **Renal Fatty Lesions**

→ **Renal Solid Tumors**

I- Renal Cysts

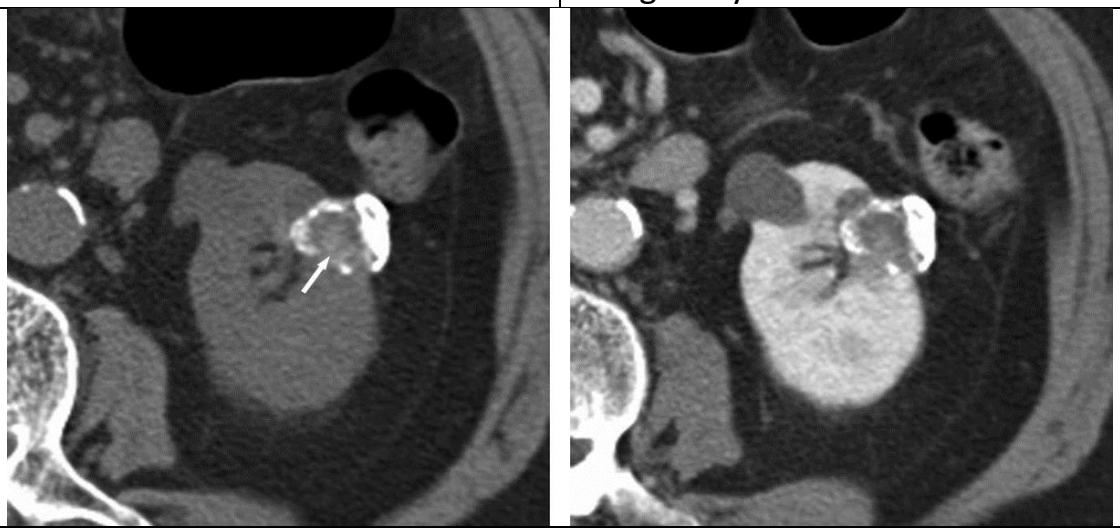
BOSNIAK CLASSIFICATION SYSTEM	
Category I	
Imaging Features	**Management**
Simple cyst Homogenous. Water density (<20HU) Thin wall No enhancement. No septations. No calcifications. No solid component	No further work-up or follow-up is necessary.
	
	

Category II

Few Thin non-enhancing septations Thin non-enhancing wall Fine calcification High-density cysts (> 20HU) <3cm No solid component	No further work-up or follow-up is necessary.
	

Category IIF

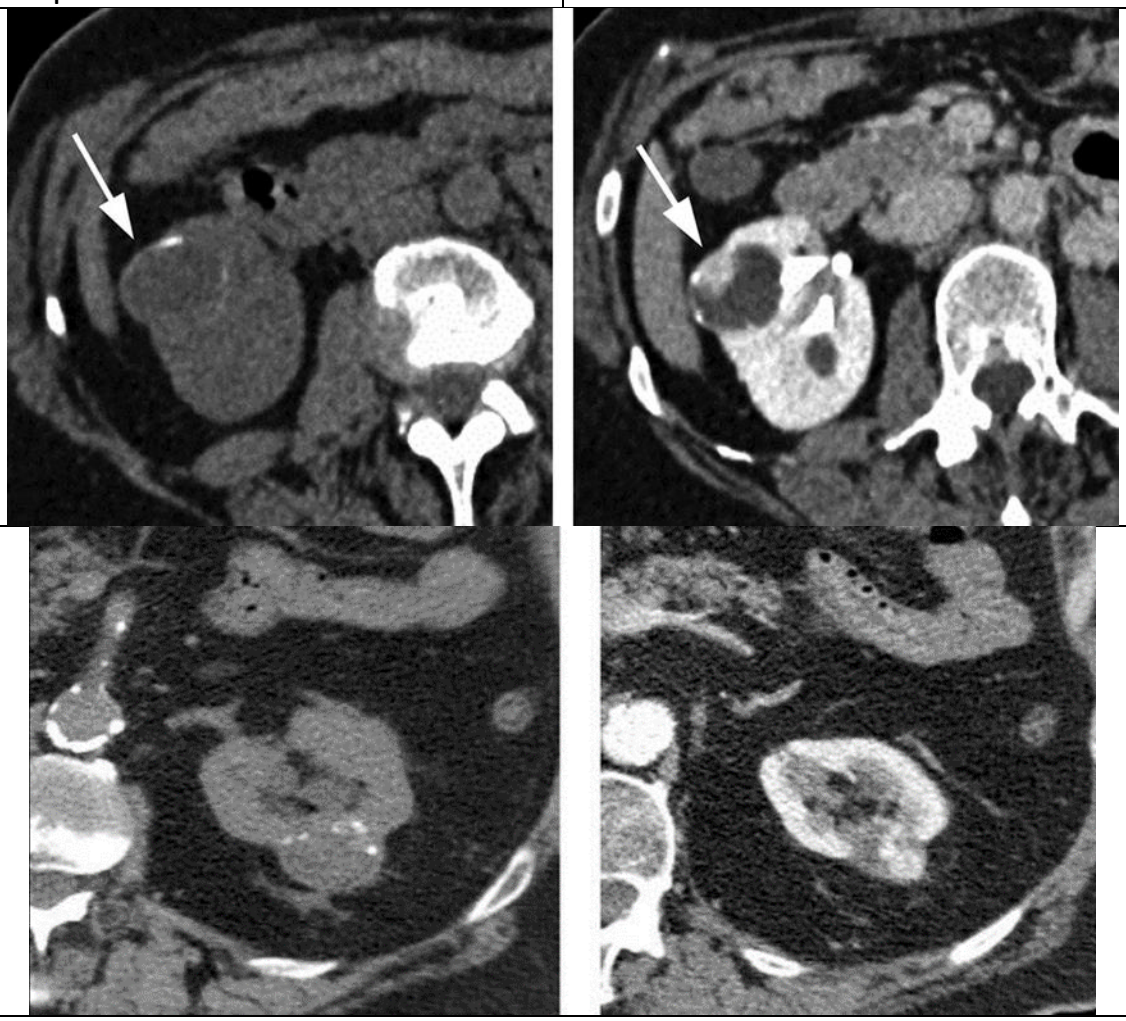
Multiple non-enhancing septations Mildly thickened non-enhancing wall Thick/Irregular/Nodular Calcification High-density cysts (> 20HU) >3cm No solid component	Require follow-up CT or MR examination Stability over time suggests that they are benign Increasing complexity indicate malignancy



Category III

Thick / irregular enhancing septations. Thick / irregular enhancing wall.	Resection is recommended.

Category IV	
Cyst with enhancing solid component	Considered malignant Resection is recommended.



❖Hyperdense Cyst Vs RCC

IN NECT:

Hyperdense Cyst > 50 HU Homogeneous

On Portal Venous (Nephrographic) Phase:

→ Masses that increase in attenuation by ≤ 10 HU considered nonenhancing hyperdense cyst.

→ Masses that increase in attenuation by > 10 HU are considered enhancing.

→ Masses that increase in attenuation by ≥ 20 HU are more specific criterion of enhancement.

In Delayed Phase:

→ De-enhancement by ≥ 15 HU indicates that the mass is solid.

→ De-enhancement by < 15 HU indicates that the mass is probably a hyperattenuating cyst.

NCCT: Hyperdense cyst 65HU	Nephrographic phase: 62HU

Renal Cystic Disease

❖Pediatric Renal Cystic Disease

- **Autosomal recessive polycystic kidney disease (ARPKD)**
- **Multicystic dysplastic kidney (MCDK)**
- **Mulitlocular cystic nephroma (MLCN)**
- **Medullary cystic disease complex**
- **Cystic Wilms tumor**

❖Adult Renal Cystic Disease

Hereditary diseases
Autosomal dominant polycystic kidney disease
Medullary cystic kidney disease
Von Hippel-Lindau disease
Tuberous sclerosis complex
Nonhereditary diseases
Acquired cystic kidney disease
Medullary sponge kidney
Multicystic dysplastic kidney
Localized renal cystic disease

1) Autosomal Dominant Polycystic Kidney Disease (ADPKD)

- 1st common hereditary renal cystic disease
- 4th leading cause of chronic renal failure in the world.

Imaging Findings:

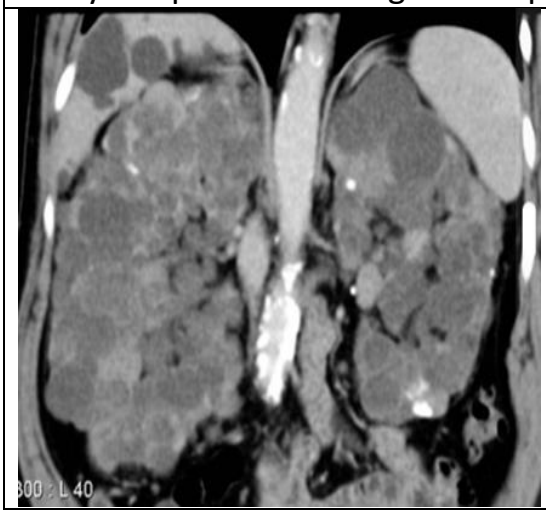
- Bilateral enlarged kidneys.
- Bosselated renal contour.
- Multiple rounded parenchymal defects (Swiss-cheese nephrogram)
- Calyceal distortion.
- Multiple variable sized cysts:
    - Hypodense / Hypointense cysts (clear watery fluid).
    - Hyperdense / Hyperintense cysts (Hge, protein, calcium)

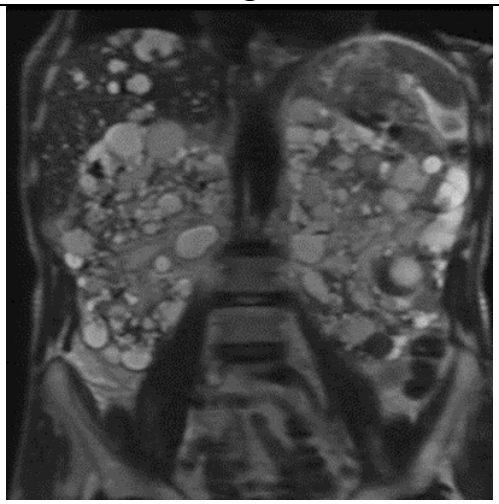
Associations:

- Extra-renal cysts:
    - Liver cysts (60%) Pancreatic cysts
    - Less common: spleen, lung, breasts, seminal vesicles, ovaries.
- Cerebral berry aneurysm.

Complications:

- Progression to end stage renal failure
- Recurrent urinary tract infections
- Cyst hemorrhage or infection-resulting in acute pain
- Cyst rupture: resulting in retroperitoneal hemorrhage





2) Autosomal Recessive Polycystic Kidney Disease (ARPKD)

- The most common ciliary disorder occurring in infants and young children
- Affects the liver and the kidney to varying degrees.
- The renal disease consists of nonobstructive, fusiform, dilated renal collecting ducts with progressive cystic degeneration + Normal nephrons.

Associations:

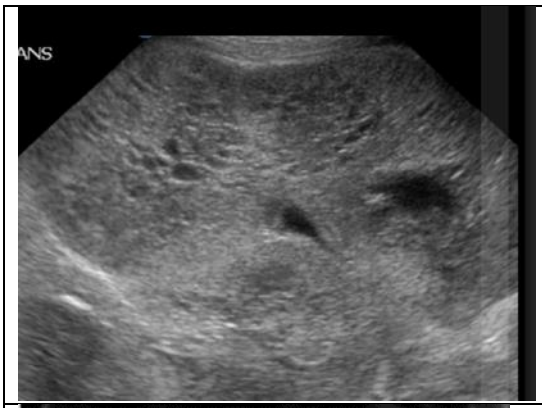
- Caroli disease
- CHF-DPM of the portobiliary system
- CHF = congenital hepatic fibrosis
- DPM = Ductal plate malformation
- Biliary ductectasia
- Porta hypertension
- Splenomegaly
- Esophageal varices

Prenatal US:

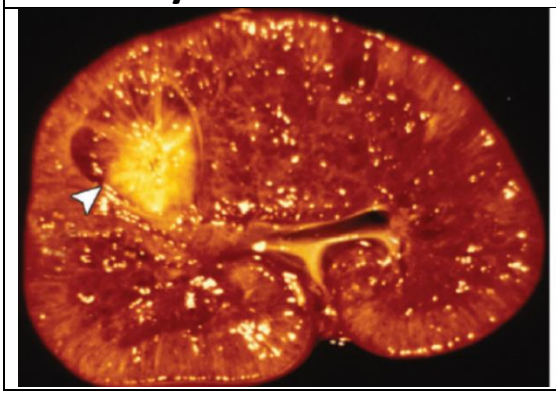
- Bilateral enlarged echogenic kidneys
- Lack of normal corticomedullary differentiation
- Oligohydramnios
- Absent or small bladder

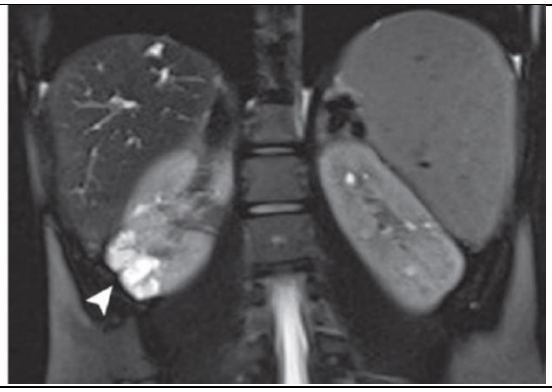
MRI:

- Enlarged kidneys
- T1: darker than normal
- T2: brighter than normal due to the large amount of urine in the dilated ducts
- Multiple rounded 1–2mm discrete tubular cystic foci
- Large 1–2cm segmental macrocysts



Macrocysts in ARPKD





3) VON HIPPEL LINDAU DISEASE (VHL)

Rare AD

Imaging findings:

- Retinal, Cerebellar, Medullary & Spinal hemangioblastoma
- Renal Cysts + tumors
- Pancreatic cysts + tumors
- Pheochromocytoma
- Endolymphatic sac tumor

4) ACQUIRED CYSTIC DISEASE OF UREMIA

- Acquired cystic kidney disease is defined by the presence of multiple renal cysts (> 3/kidney) in a patient with end-stage kidney disease due to a cause other than hereditary renal cystic disease

Prevalence of ACKD in dialysis patients

After 1-3 years: 10-20%
After 3-5 years: 40-60%
After 5-10 years: > 90%

Bi Small Kidneys + Bi Multiple Small Cysts.	RCC in 7% of ACKD

5) Multicystic Dysplastic Kidney (MCDK)

2nd common cause of neonatal abdominal mass (after hydronephrosis).
40% has contralateral renal abnormalities (VUR & UPJO).

Imaging findings:

- Non functinal kidney replaced by cysts.
- Multiple variable sized cysts
- Cysts are not interconnected (D.D hydronephrosis)
- Central region of solid tissue
- No normal renal parenchyma.
- No renal pelvis.
- No ureter.
- No renal vessels

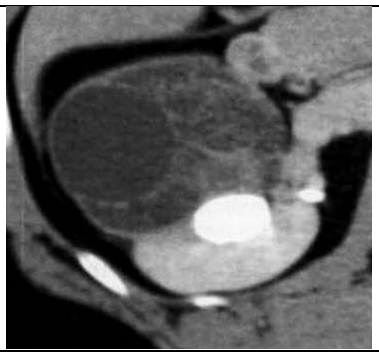
6) Multilocular Cystic Nephroma

<u>2 histological subtypes / Biphasic Age & Sex distribution:</u>

- **Multilocular cystic nephroma (MLCN):**
  - **1/3; Adult women; theoretical risk of cystic RCC**
- **Cystic partially differentiated nephroblastoma (CPDN):**
  - **2/3, young boys; theoretical risk of cystic wilms' tumor.**

<u>Imaging findings => Bosniak III</u>

- Multilocular cystic mass containing multiple tiny cysts.
- Septations may enhance.
- Curvilinear Calcification
- ± Distortion of collecting system or herniation of mass into renal hilum



7) Medullary Cystic Disease Complex

- Characterized by progressive tubular atrophy with glomerulosclerosis (chronic tubulointerstitial nephritis) and multiple small medullary cysts.
- Clinical triad = uraemia + anaemia + salt wasting (hyponatremia, hypokalemia)

<u>3 clinical variants based on age of onset for end stage renal disease - ESRD:</u>

- Infantile - before 2 years of age
- Juvenile - also called nephronopthisis: most common form, age of onset 10 years
- Adolescent - also called medullary cystic kidney disease, usually develops in the 30s

<u>Imaging findings:</u>

- Normal to small kidneys
- Multiple small (1.5cm>) medullary cysts

8) Mixed Epithelial and Stromal Tumor of the Kidney (MEST)	9) Adult cystic nephroma (ACN)	10) Cystic RCC
• Rare benign lesion		Malignant tumor
Perimenopausal women		**M>F, >50y**
Complex cystic lesion Bosniak III or IV		

II- Renal Fatty Lesions

Renal Angiomyolipoma

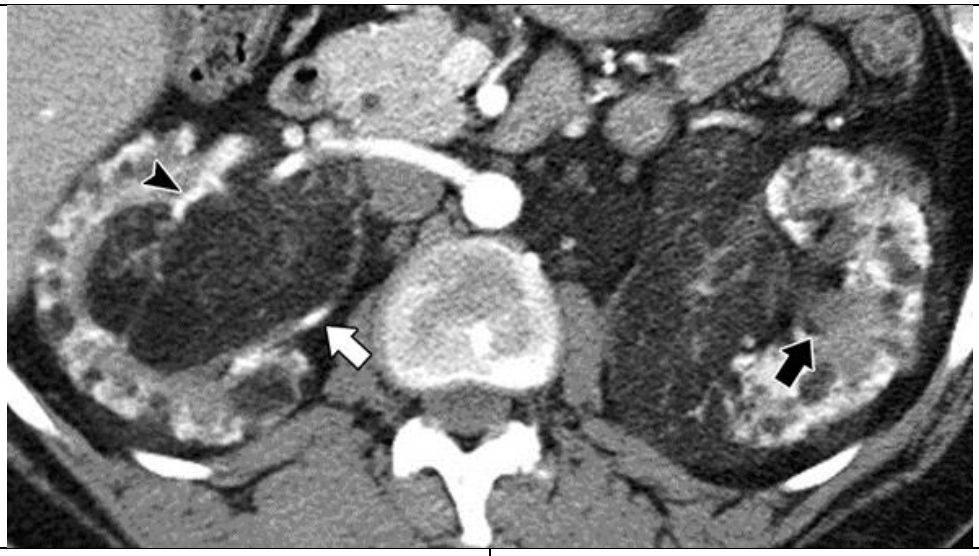
- Most common benign tumor of kidney.
- Angiomyolipomas are benign renal hamartomatous tumors composed of varying amounts of:
  a) mature adipose tissue,
  b) smooth muscle, and
  c) abnormal blood vessels.

Sporadic AML	Inherited AML
80%	**20%**
Unilateral	**Multiple & bilateral**
Usually not associated with tuberous sclerosis	**Usually due to tuberous sclerosis 80% of tuberous sclerosis patients have renal AMLs**
F > M = 4:1	**M:F = 1:1**

Imaging findings:

- Well defined cortical lesion
- US: Hyperechoic
- CT:
  - Predominant Fat density lesion
  - Predominant Highly vascular lesion + hypodense fat foci within
  - Calcifications is rare.
  - Enlarged vessels coursing through the lesion
  - ± superimposed aneurysms
  - o ± signs of associated hemorrhage
  - Exophytic renal AML + a defect in the renal capsule where the lesion is attached helps to confirm its renal origin.
- MRI:
  - T1 & T2: Hyperintesne fat signal lesion
  - Fat suppression sequence: Loss of signal

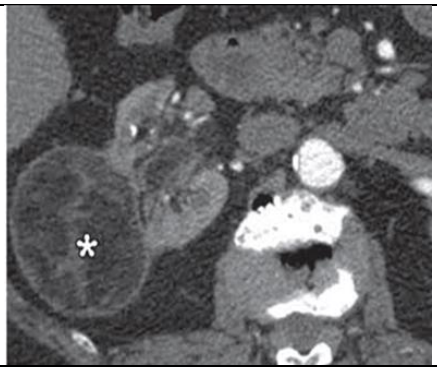
Multiple bilateral AML in TS

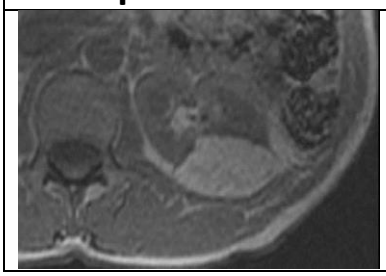
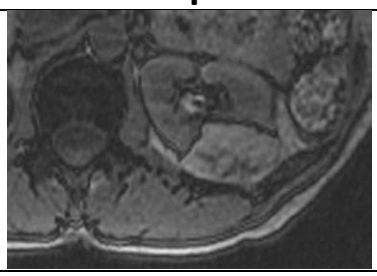
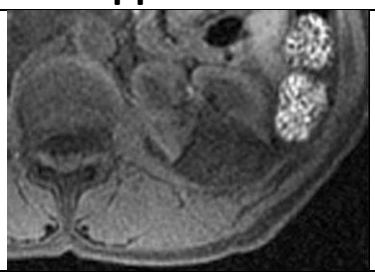


Predominate fat density lesion

Predominant highly vascular lesion + fat density foci within

Exophytic renal AML: Cortical defect + crossing vessels



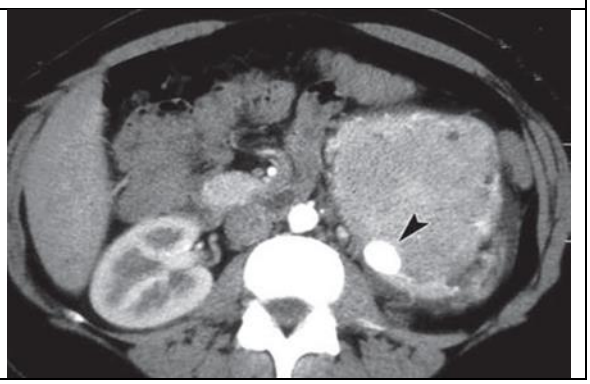
MRI		
T1 In-phase	**T1 Out-of-phase**	**Fat suppression**
		

❖ Complications

- Hemorrhage and renal failure.
- Approximately 25% of AML may manifest with spontaneous rupture and hemorrhage.
    - Tumor size > 4 cm
    - Intratumoral aneurysms > 5 mm

Perinephric hemorrhage

Intra-lesion pseudo-aneurysm



III- WHO Classification of Renal Neoplasms 2004

- **Renal cell tumors**
- **Metanephric tumors**
- **Nephroblastic tumors**
- **Mesenchymal tumors**
- **Mixed mesenchymal and epithelial tumors**
- **Neuroendocrine tumors**
- **Hematopoietic and lymphoid tumors**
- **Germ cell tumors**
- **Metastatic tumors**

❖Renal Cell Tumors

- Clear cell RCC
- Papillary RCC
- Chromophobe cell RCC
- Collecting duct of Bellini carcinoma
- Medullary carcinoma
- Mucinous tubular and spindle cell
- Renal cell carcinoma; Unclassified
- Papillary adenoma
- Oncocytoma

❖Metanephric Tumors

- Metanephric adenoma
- Metanephric adenofibroma
- Metanephric stromal tumors

❖Nephroblastic tumors

- Nephrogenic rests
- Nephroblastoma

❖Mesenchymal Tumors in Adults

Benign tumors	Malignant tumors
Angiomyolipoma (including epithelioid type)	Leiomyosarcoma
Leiomyoma	Rhabdomyosarcoma
Hemangioma	Angiosarcoma
Lymphangioma	Osteosarcoma
Juxtaglomerular cell tumor	Synovial sarcoma
Renomedullary interstitial cell tumor (medullary fibroma)	Fibrosarcoma
Lipoma	Malignant fibrous histiocytoma
Solitary fibrous tumor	Solitary fibrous tumor
Schwannoma	

❖Mesenchymal Tumors in Pediatric

- Clear cell sarcoma
- Rhabdoid tumor
- Congenital mesoblastic nephroma
- Ossifying enal tumor of infants.

❖Mixed mesenchymal and epithelial tumors

- Cytsic nephroma
- Mixed epithelial and stromal tumor
- Synovial sarcoma

❖Neuroendocrine tumors

- Carcinoid
- Neuroendocrine carcinoma
- Primitive neuroendocrine tumor
- Neuroblastoma
- Pheochromocytoma

❖Haematopoietic and lymphoid tumors

- Lymphoma
- Leukaemia
- Plasmacytoma

❖Germ cell tumors

- Teratoma
- Choriocarcinoma

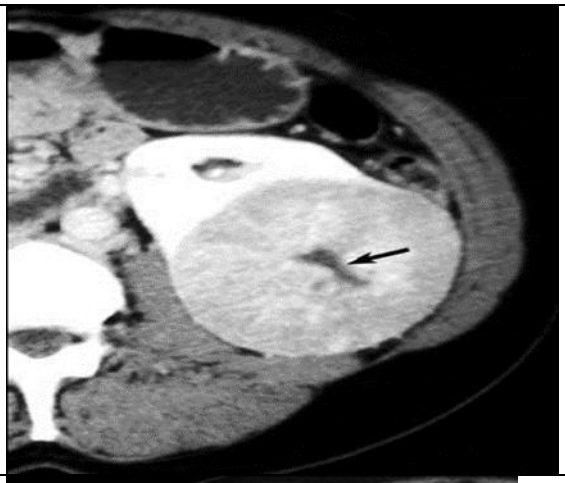
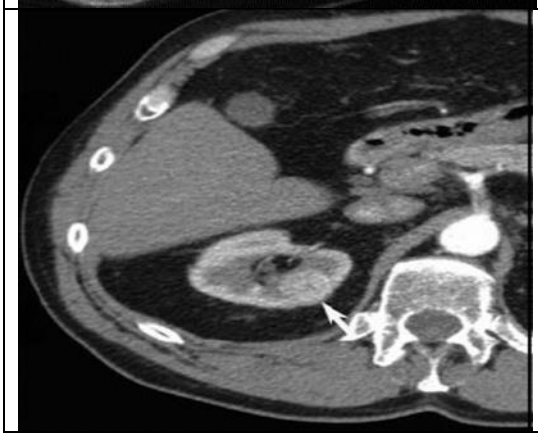
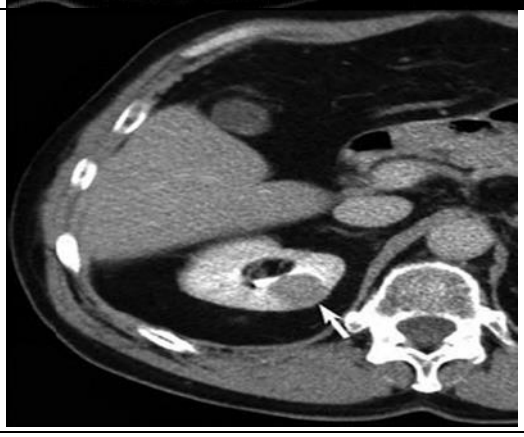
Renal Oncocytoma

- Uncommon renal neoplasm.
- 2nd Most common benign renal tumor after AML.
- Originate from epithelium of proximal tubules.

- **Even when all typical imaging features are present, there is significant overlap with RCC, so diagnosis of oncocytoma can't be made on imaging alone.**

Imaging findings:

- Well defined homogeneously renal mass
- Pseudocapsule
- Central non-enhancing stellate scar
- "Spoke-wheel" pattern: Internal radiating low signal areas
- Homogenous enhancement

Renal Cell Carcinoma

- Renal tumors account for 3% of all adult malignancies.
- RCC account for 90–95% of all renal tumors.
- RCC is the 6th leading cause of cancer death.

- Age: Sixth and seventh decades of life.
- Sex: males (two- to threefold increased risk).

Risk factors:

- Cigarette smoking, which doubles risk.
- Obesity.
- heavy analgesic use.
- Tuberous sclerosis.
- Von-Hippel-Lindau disease.
- Acquired cystic renal disease associated with long term hemodialysis.
- Immunosuppressant for renal transplants.

Histopathology

- Renal cell carcinoma arises from renal tubular epithelium and usually develops in the cortex of the kidney
    - Clear cell (most common 75–85%)
    - Papillary
    - Chromophobe cell
    - Collecting duct
    - Medullary
    - Mucinous tubular and spindle cell
    - Unclassified

Imaging findings:

- Well defined expansile mass.
- Calcifications: irregular central calcifications
- A focal contour bulge in the renal surface is typical.
- Heterogeneous enhancement, show areas of necrosis or hemorrhage.
- Cystic RCC: 25% Bosniak IV cysts

Robson Classification

Stage I: Confined to kidney
Stage II: through renal capsule but confined to Gerota's fascia
Stage IIIA: involvement of renal vein or IVC
Stage IIIB: involvement of local lymph nodes
Stage IIIC: involvement of vessel(s) and nodes
Stage IV: spread to local organs or distant metastases

TNM Classification

Primary tumor (T)

- TX: primary tumor cannot be assessed
- T0: no evidence of primary tumor
- T1: Tumor < 7 cm limited to the kidney.
  - T1a <4cm
  - T1b >4cm <7cm
- T2: Tumor > 7 cm limited to the kidney.
  - T2a >7cm <10cm
  - T2b >10cm
- T3a: Tumor invades adrenal gland or perinephric tissues but not beyond Gerota's fascia
- T3b: tumor grossly extends into the renal vein or IVC below diaphragm
- T3c: tumor grossly extends into the renal vein or IVC above diaphragm
- T4: tumor invades beyond Gerota's fascia or ipsilateral adrenal gland.

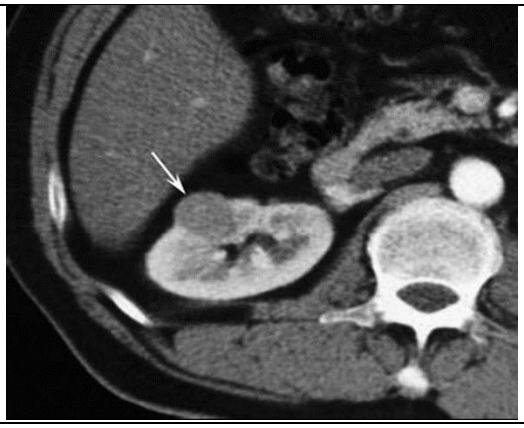
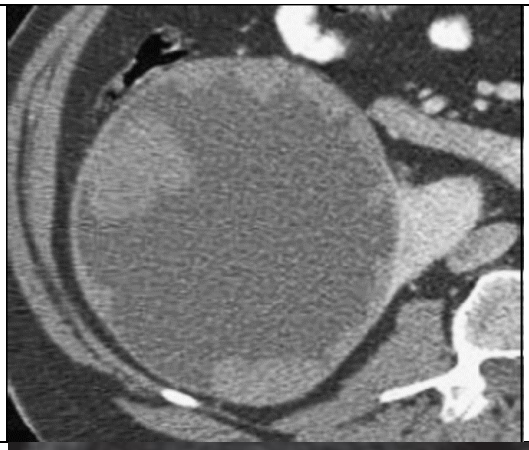
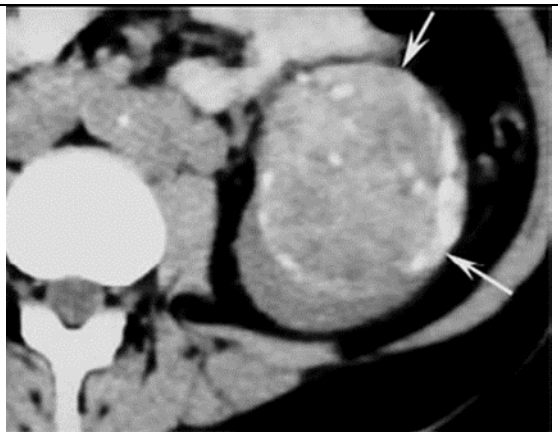
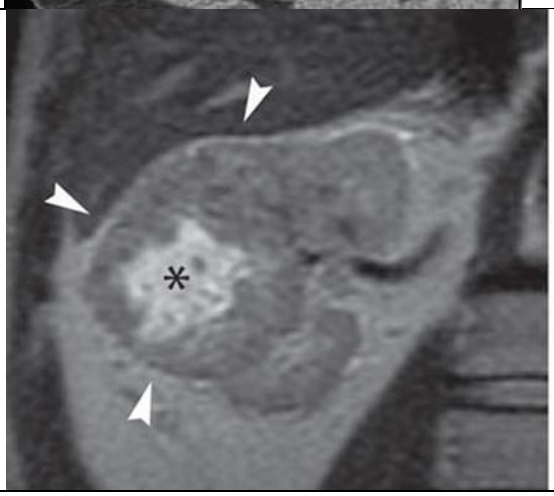
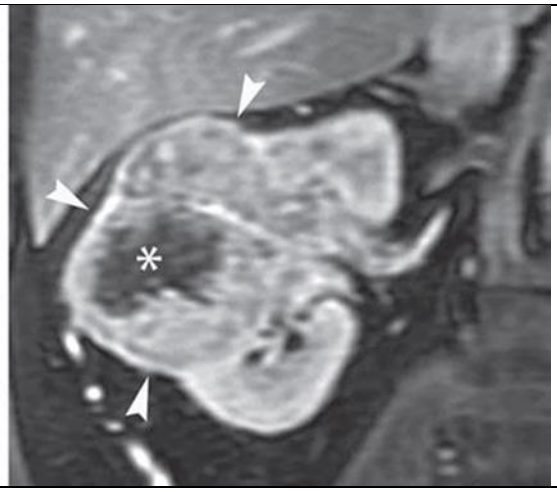
Regional lymph nodes (N)

NX: regional lymph nodes cannot be assessed.
N0: no regional lymph node metastasis
N1: metastasis in a single regional lymph node
N2: metastasis in more than one regional lymph node (Renal hilar LNs & Retroperitoneum para-aortic and para-caval LNs)

Distant metastasis (M)

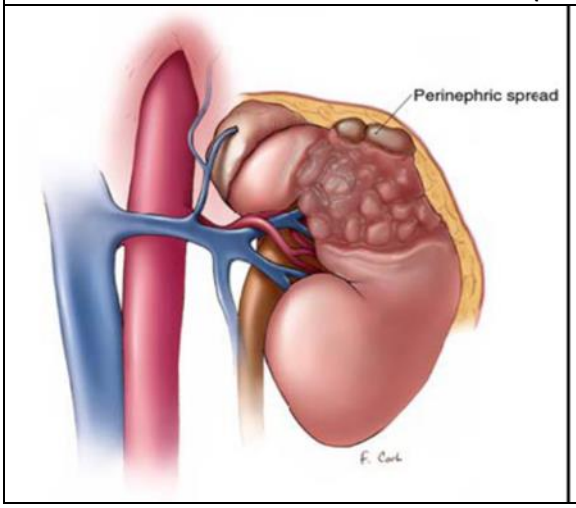
- MX: distant metastasis cannot be assessed
- M0: no distant metastasis
- M1: distant metastasis to organs or non-regional LNs (mediastinal – hilar – Supraclavicular LNs)

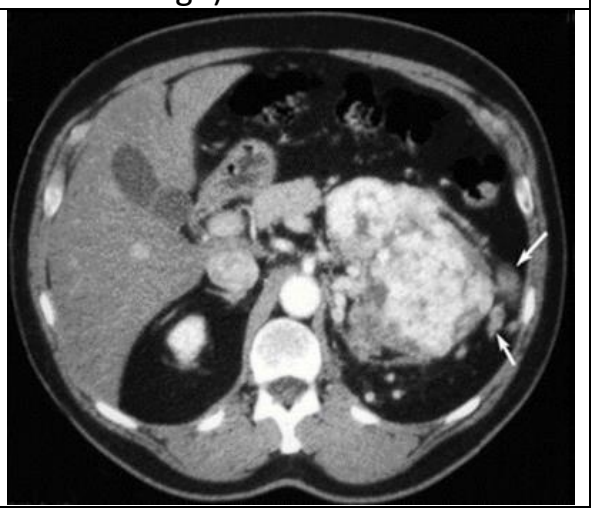
Stage I: Confined to Renal Capsule

Clear Cell Type High tumor-to-parenchyma enhancement ratio	**Papillary Type** Low tumor-to-parenchyma enhancement ratio
	
Cystic RCC	**Calcifications**
	
	

Stage II: Extracapsular / Perinephric tumor spread:

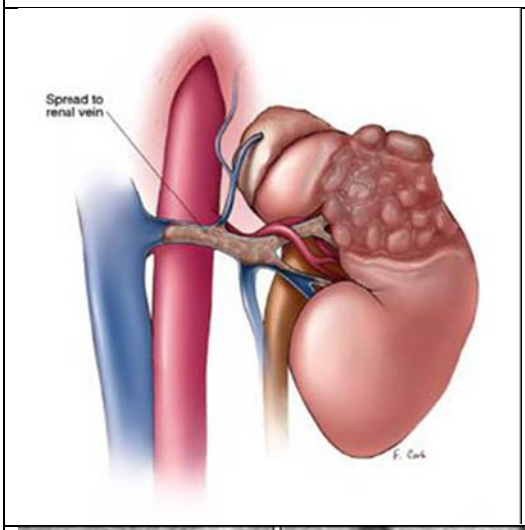
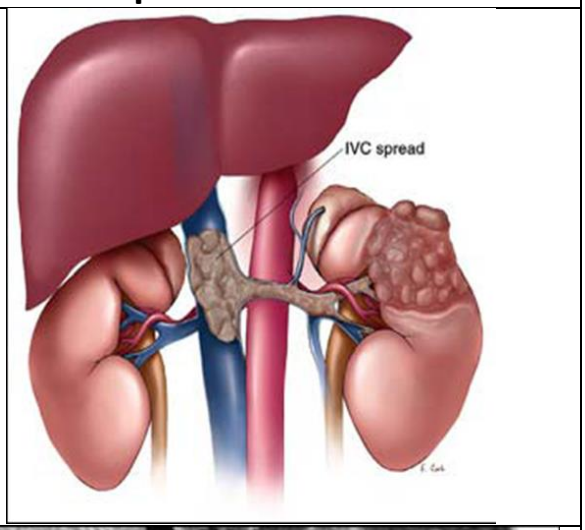
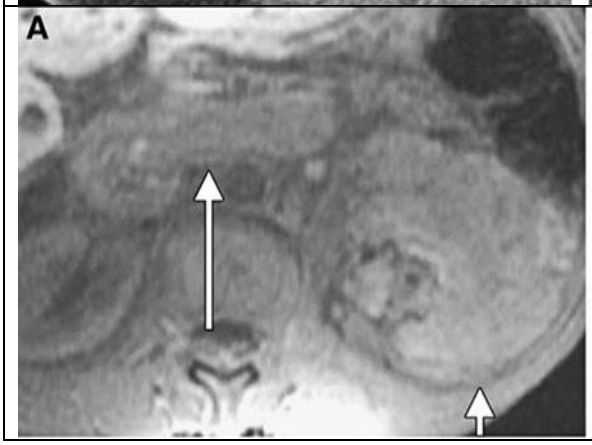
- Fat obliteration of the perinephric space
- Collateral vessels
- Stranding or cobwebbing
- Fascil thickening;
- Discrete soft tissue masses (most reliable sign).





Stage III A: Venous Spread

- The most specific sign:
  - a low-density filling defect within the renal vein.
- 2ry signs:
  - An abrupt change in the caliber of the renal vein.
  - The presence of a clot within collateral veins.
  - Renal vein enlargement and displacement.
- Malignant thrombus:
  - Heterogeneous enhancement of the thrombus with contrast indicates neovascularity, and thus, tumor thrombus.
  - Direct continuity of the thrombus with the primary tumor suggests tumor thrombus.

Tumor spread limited to the renal vein	Tumor spread into the infrahepatic IVC
	
	

Stage III B: Regional LNs:

- Renal hilar LNs & Retroperitoneum para-aortic and para-caval LNs
- Nodal enlargement above 1 cm short-axis diameter.
- The enhancement pattern within the node may also help differentiate reactive from malignant adenopathy: metastatic nodes may enhance, particularly if the primary tumor is very vascular

Stage IV A: Local Extension:

Direct extension of RCC outside Gerota's fascia into neighboring organs:

- Focal change in attenuation within the adjacent organ.
- Loss of tissue planes and irregular margins between the tumor and surrounding structures raise the possibility of direct infiltration.

STAGE IV B: Distant Metastasis

- Most common: Lungs, mediastinum, bones, and liver.
- Less common: The contralateral kidney, the adrenal gland, brain, pancreas, mesentery, and abdominal wall.
- Like the primary tumor, metastatic lesions tend to be hypervascular.

A

Renal TCC

- Transitional cell carcinoma of the kidney arises from the urothelium of the renal pelvis or calices overlying the renal parenchyma.
- 10%–15% of all renal tumors

- Age: Sixth & Seventh decades of life.
- Sex: M>F by 3 times.

Location of Urothelial Tumors

- 95% UB
- 5% Upper urinary tract
    - 75% Renal pelvis / calices
    - 25% Ureter

Risk Factors

- Smoking (most important risk factor)
- Chemical carcinogens (aniline, benzidine, aromatic amine, azo dyes).
- Cyclophosphamide therapy.
- heavy caffeine consumption.
- Analgesic abuse.

Uroepithelial tumors:

- 90% Transitional cell carcinoma
- 9% squamous cell carcinoma
- 1% adenocarcinoma

Metachronous tumor

- 50% of patients with upper-tract TCC develop metachronous tumor in the bladder.
- 13% of patients with upper-tract TCC develop metachronous tumor in the upper-tract.
- 6% of patients with bladder TCC develop metachronous tumor in the upper-tract.

Synchronous Tumor

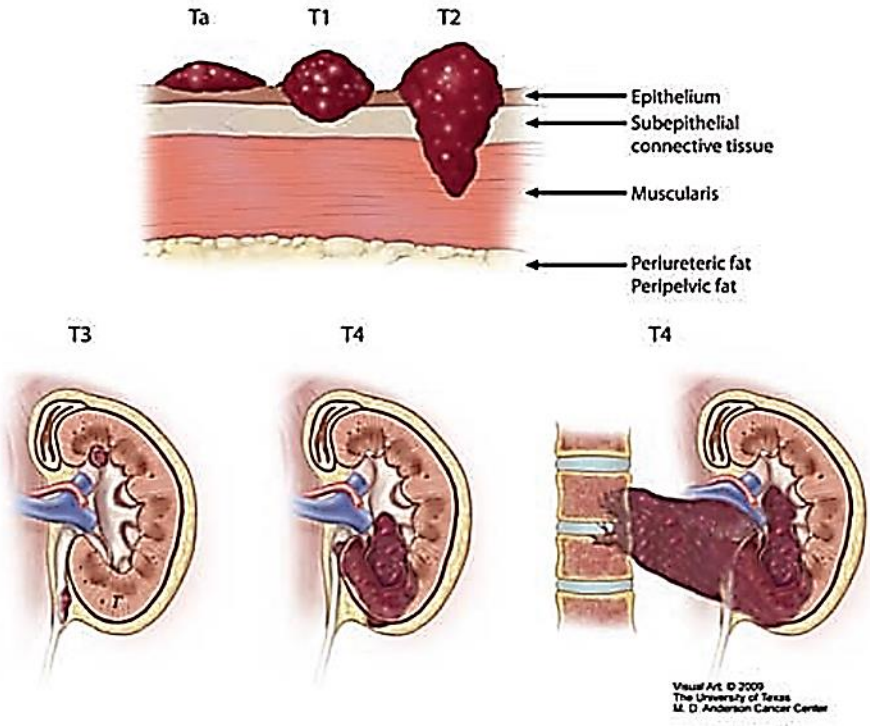
- 2% of patients with renal TCC have synchronous bilateral TCC.
- 2% of patients with renal TCC have synchronous urinary bladder TCC.
- 2% of patients with bladder TCC have synchronous upper-tract tumor.

TNM Classification

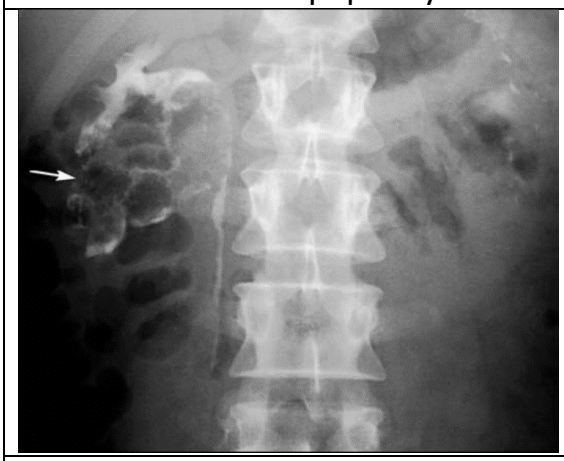
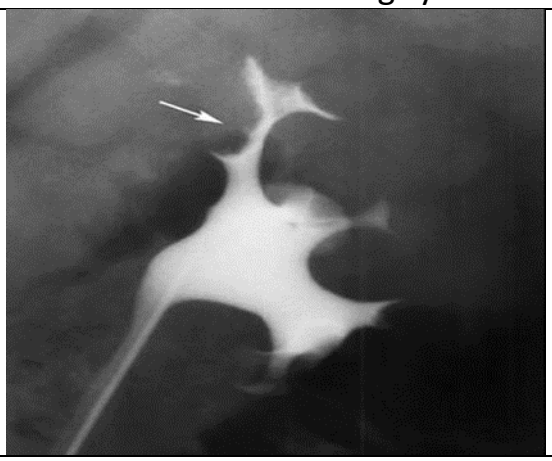
Tx Primary tumor cannot be assessed
T0 No evidence of primary tumor
Ta Papillary non-invasive carcinoma
Tis Carcinoma in situ
T1 Tumor invades subepithelial connective tissue
T2 Tumor invades the muscularis propria
T3 Tumor invades periureteric / peripelvic fat or the renal parenchyma
T4 Tumor invades adjacent organs, pelvic/abdominal wall, or through the renal capsule into perinephric fat

Nx Regional lymph nodes cannot be assessed
N0 No regional lymph node metastasis
N1 Single LN < 2 cm
N2
Single LN 2 - 5 cm
Multiple LNs < 5 cm
N3 Single or multiple LNs >5 cm

Mx Distant metastases cannot be assessed
M0 No distant metastasis
M1 Distant metastasis



IVU Findings:

Stipple Sign:	Filling defect:
Refers to tracking of contrast into the interstices of a papillary lesion .	Filling defect within the contrast-enhanced renal collecting system.
	
Amputated Calyx:	**Oncocalyx /phantom calyx:**
Filling defects within dilated calices may occur secondary to tumor obstruction of the infundibulum.	If TCC involves an infundibulum, then an “amputated” calyx may be seen with focal hydronephrosis

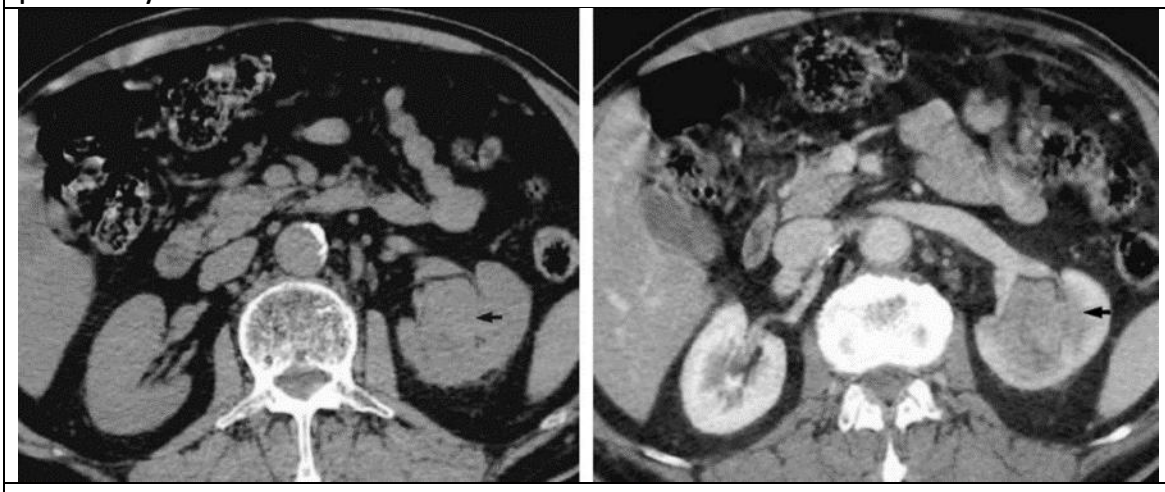
Imaging findings:

- Centered on renal pelvis => expands centrifugally => compression of the renal sinus fat
- Early TCC: are separated from the renal parenchyma, either by renal sinus fat or excreted contrast.
- Infiltrative TCC: Invasion of renal parenchyma
- NCCT: Soft tissue density (8-30HU) (hyperdense relative to urine)
    - DD: Clot (40–80 HU) or calculus (>100 HU)
- Nephrographic phase: Mild enhancement (18-55HU) (less enhancing than renal parenchyma)
- Excretory phase: filling defect within excreted contrast material.

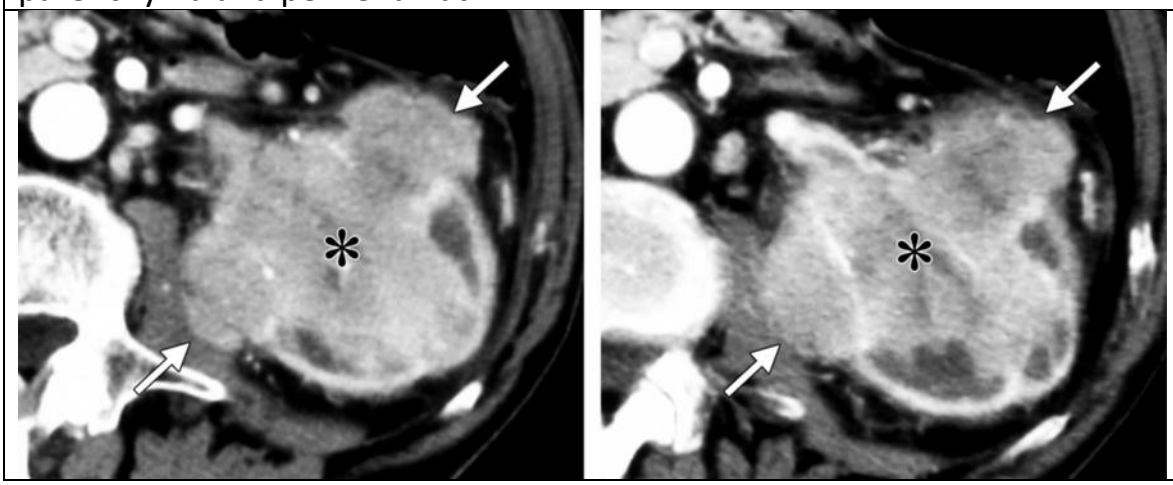
CTUT: Mildly enhancing soft-tissue mass (arrows) in the renal pelvis

CTUT: Filling defect in the renal pelvis

T3: Mildly enhancing soft-tissue mass (arrows) in the upper portion of the renal pelvis and upper pole renal calix extending to upper pole renal parenchyma.



T4: Large infiltrative central renal mass with invasion of the renal parenchyma and perirenal fat

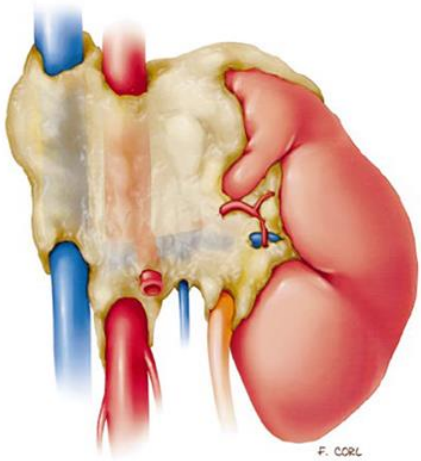


Renal Lymphoma

- The genitourinary system is the second most commonly affected anatomic entity next to the hematopoietic and reticuloendothelial organs.

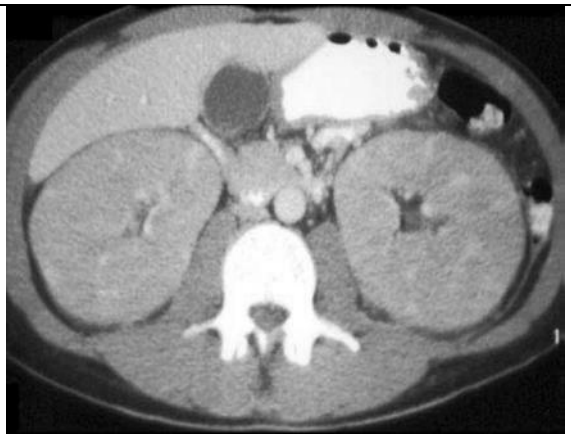
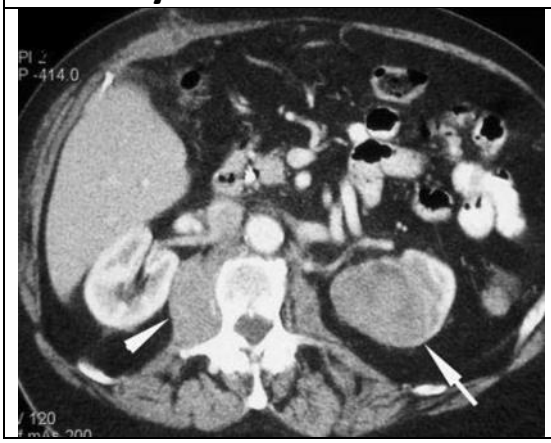
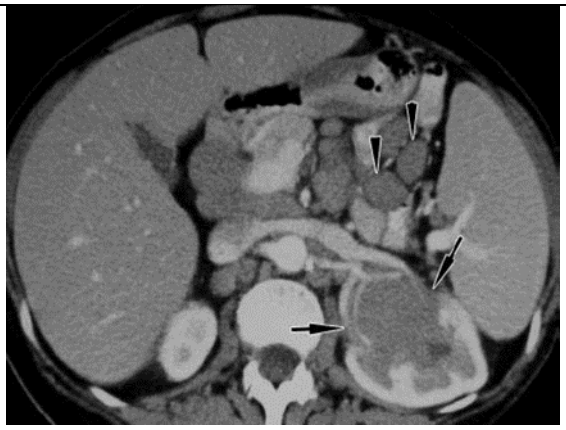
6 patterns

- Multiple bilateral renal masses (50-60%)
- Solitary renal mass in one kidney (15%)
- Direct extension from retroperitoneal mass invading the kidney (25%)
- Perirenal lymphoma (10%)
- Diffuse parenchymal infiltration (10%) of one or both kidneys ~ diffuse enlargement.
- Renal sinus involvement (Rare)

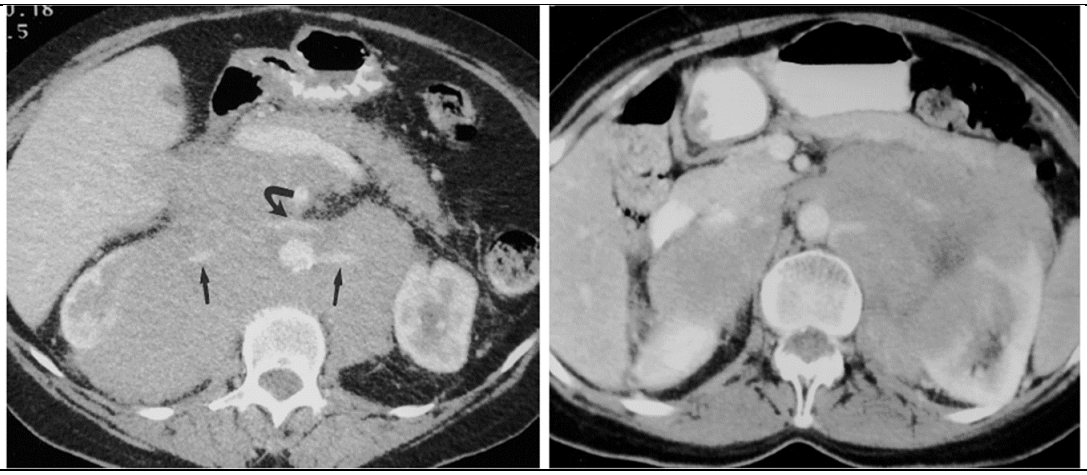
Multiple Renal Masses	Solitary Renal mass
Retroperitoneum Mass	**Perirenal Lymphoma**
	

Imaging Findings:

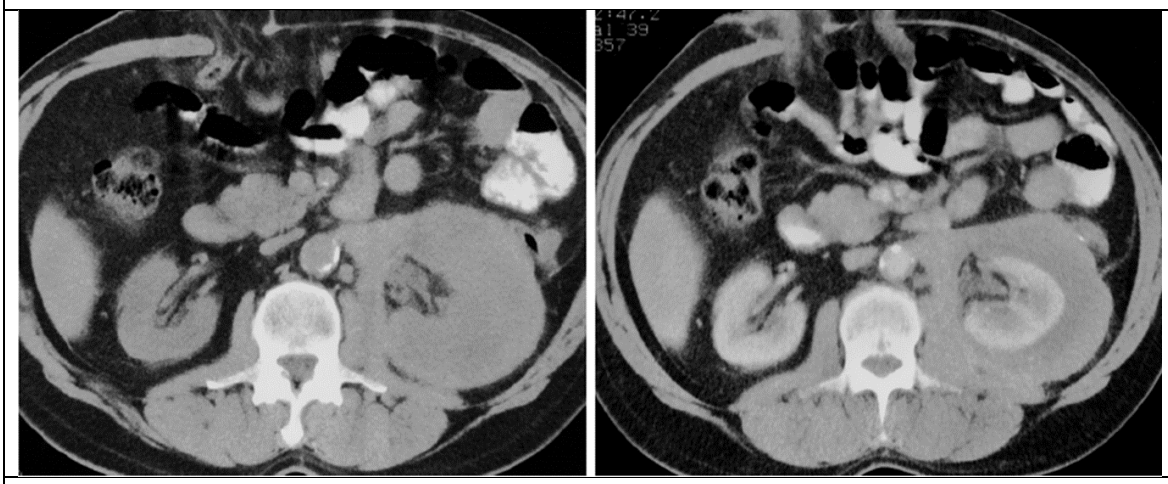
- Homogeneous
- Not deform the renal contour
- US: Hypoechoic
- CT: Hypodense
- T1: hypointense
- T2: Isointense or hypointense
- +C Venous phase: Hypovascular = minimal enhancement (10-20 HU)
- PETCT: increased metabolic activity

Bi renal masses	Bi diffuse renal enlargement
	
Solitary renal mass	**Renal sinus mass**
	

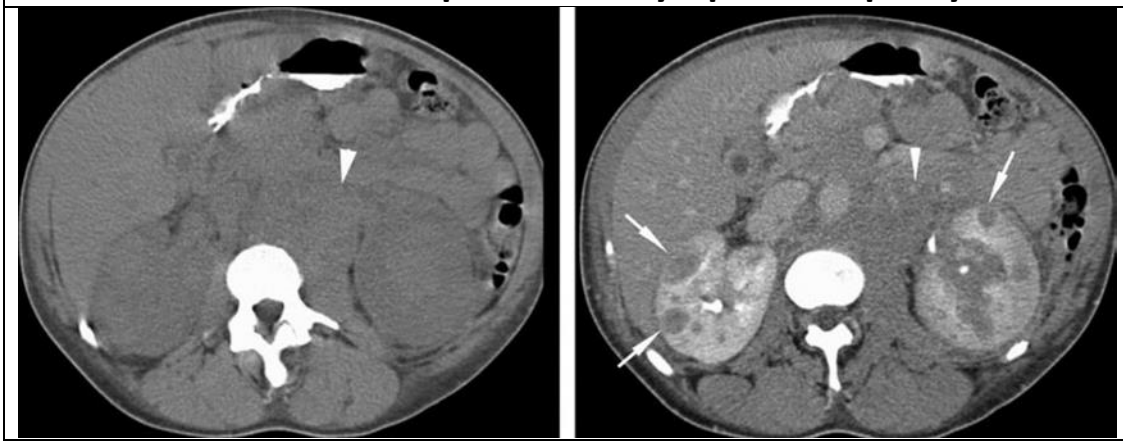
Retroperitoneal mass invading kidney



Perirenal mass



Bi Renal Masses + Retroperitoneal Lymphadenopathy



Pediatric Renal Tumors

1) Wilms' Tumor

- 1st common solid renal tumor of childhood.
- 3rd common renal mass of childhood (after hydronephrosis & multicystic dysplastic kidney)
- 3rd common malignancy in children (after leukemia & brain tumors)

- **Age: < 5y**

Role of 10%:

10% Bilateral.
10% Multiple.
10% Unfavorable histology.
10% Calcification
10% Vascular invasion.
10% Pulmonary metastasis.

Associations:

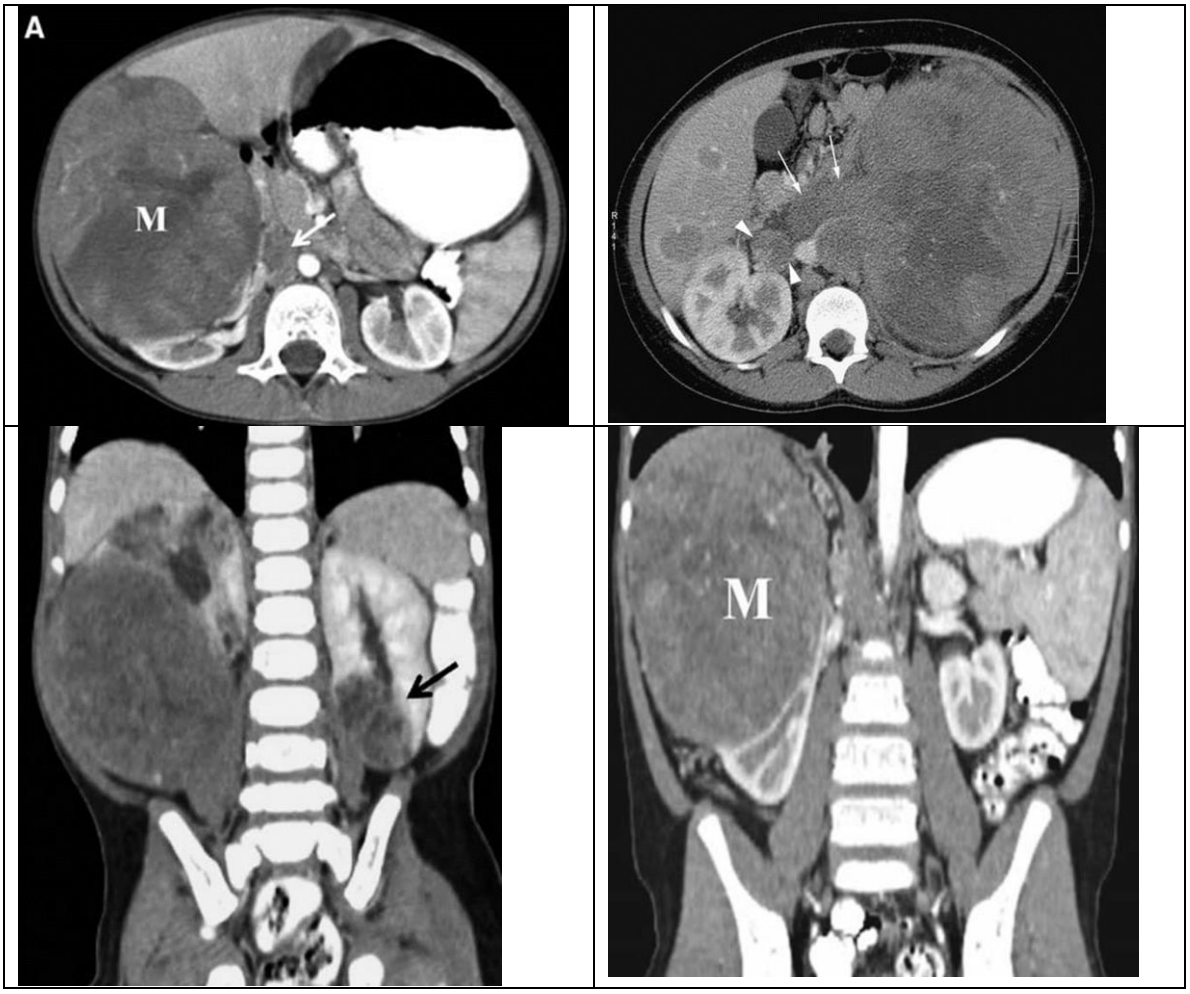
- Beckwith-Wiedemann syndrome: Macroglossia, omphalocele, visceromegaly.
- Denys-Drash syndrome (Triad): Wilms + Ambiguous genitalia + Glomerulonephritis.
- WAGR syndrome: Wilms tumor, aniridia, genitourinary malformation, mental retardation
- Hemihypertrophy

Staging: (Similar to RCC in adults)

Stage I: Confined to the kidney.
Stage II: Extension into perinephric space.
Stage III: LN involvement &/or Venous invasion.
Stage IV: Metastasis.
Stage V: Bilateral renal involvement

Imaging findings:

- A large renal mass
- Low density (compared to the renal parenchyma)
- Heterogeneous enhancement (due to areas of necrosis & Hge)
- Calcifications are less common (10%)
- Surrounded by pseudo capsule (compressed renal parenchyma)
- Distortion of the pelvicalyceal system.



2) Mesoblastic Nephroma

- ***Most common renal mass in Neonates.***
- It is a benign hamartoma.
- Solid and homogenous mass

Wilms' tumor	Mesoblastic Nephroma
Children < 5 y	*Infants < 1y*
Solid Tumor	*Solid Tumor*
Malignant	*Benign hamartoma*
Necrosis & Hge common	Necrosis & Hge rare
Vascular invasion	No vascular invasion
Metastasis	No metastasis

3) Nephroblastomosis = Nephrogenic Rests:

- Precursors of Wilms tumor.

Present in:

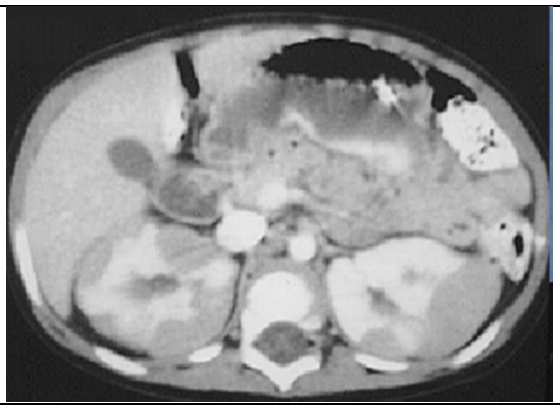
- 30% of unilateral Wilms' tumor
- 100% of bilateral wilms' tumor

2 forms on the basis of location:

- Perilobar rests = at the periphery of renal lobe
- Intralobar rests = within renal lobe

Imaging findings:

- Multiple or diffuse
- Subcapsular
- Hypovascular
- Soft tissue mass lesions



4) Rhabdoid Tumor

- ***Rare malignant renal tumor in infants.***
- Highly aggressive
- Metastasis to lung, liver, brain.
- Poor prognosis.

Associated with Brain tumors :

- Posterior fossa PNET= AT/RT = Atypical Teratoid Rhabdoid Tumor & Medulloblastoma
- Supratentorial PNET

Differential Diagnosis

LARGE SMOOTH KIDNEY		
Unilateral	**Bilateral**	
• **Acute pyelonephritis** • **Acute Renal vein thrombosis** • **Acute obstructive uropathy** • **Acute Arterial obstruction** • **Compensatory hypertrophy**	• Acute GN • Acute PN • Acute CN • Acute TN • Acute IN	• Lymphoma • Leukemia • Amyloidosis • MM

SMALL SMOOTH KIDNEY	
Bilateral	**Unilateral**
End stage renal parenchymal disease: • Chronic glomerulonehritis. • Arteriolar nephrosclerosis. • Late DM • Late Amyloidosis. • Collagen disease	• Chronic renal artery stenosis • Congenital hypoplasia.

Small Scarred kidney	
• Chronic atrophic pyelonephritis. • Renal TB • Renal infarction	• Splenic impression • Fetal lobulation.

Urinary System

Ureter

Congenital Anomalies of the Ureter

A- Primary Vesicoureteral Reflux

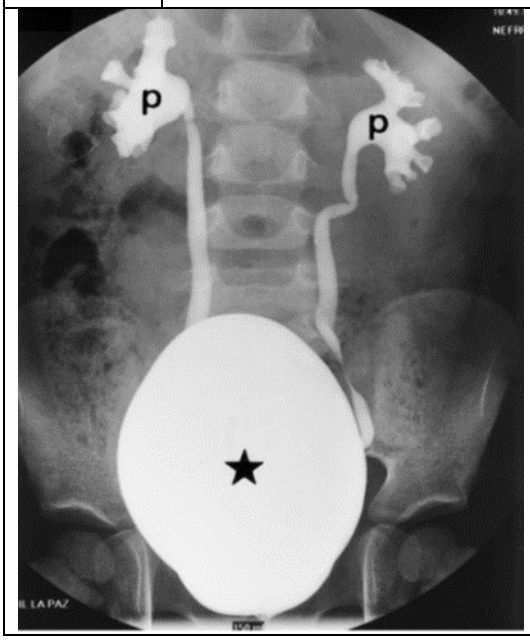
- it occurs as a result of a primary maturation abnormality of the vesicoureteral junction or a short distal ureteric submucosal tunnel in the bladder that alters the function of the valve mechanism

- Reflux predisposes to renal infection (pyelonephritis) because it carries bacteria from the bladder to the upper urinary tract.
- Reflux nephropathy is a common cause of renal failure.

- ***The primary diagnostic evaluation of VUR is VCUG (voiding cystourethrography)***

❖Grades of VUR:

I	Ureter only
II	Ureter and pelvicalyceal system No pelvicalyceal dilatation
III	Mild dilatation of the ureter and pelvicalyceal system
IV	Moderate dilatation of the ureter and pelvicalyceal system
V	Marked dilatation of the ureter and pelvicalyceal system



B- Primary Megaureter

Normal ureter < 5mm
Megaureter > 7 mm

3 major categories of primary megaureter:

1) Obstructed primary megaureter,
2) Refluxing primary megaureter,
3) Non-refluxing unobstructed primary megaureter

Secondary megaureter:

occurs as a result of some abnormality involving the bladder or urethra: Urethral valves, neuropathic bladder dysfunction, urethral strictures, ureteroceles, acquired causes of obstruction.

1) Obstructed Primary Megaureter

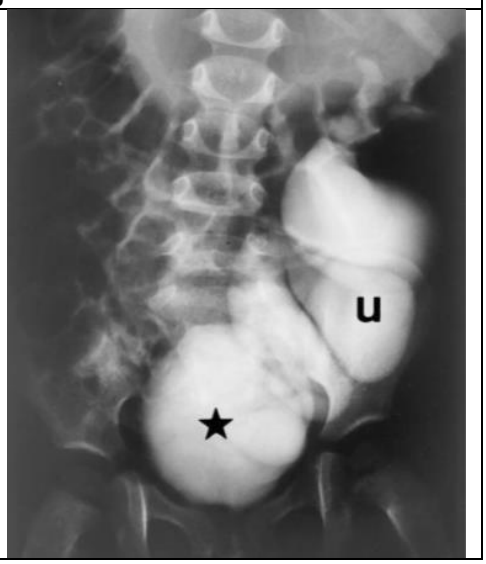
- Dilatation above a short (0.5–4-cm) aperistaltic, normal-caliber juxtavesical section of a normally inserted ureter.
- Normal ureteral orifice and the submucosal tunnel.
- This phenomenon is similar to achalasia and Hirschsprung disease.

2) Refluxing Primary Megaureter

- Short or absent intravesical ureter
- Congenital paraureteric diverticulum,
- Other derangement of the vesicoureteral junction

3) Nonrefluxing Unobstructed Primary Megaureter

- Neither reflux nor stenosis of the vesicoureteral junction
- Ureter is dilated beginning at a point just above the bladder
- The cause of this phenomenon is unknown
- Most primary megaureter in neonates falls into this category



C- Ectopic Ureter

In female ectopic ureter inserts into:

- Lower bladder, urethra, vestibule, or vagina.
- More rarely, it can empty into the uterus or a wolffian duct remnant such as Gartner duct or cyst.

In male ectopic ureter inserts into:

- Lower bladder, posterior urethra, seminal vesicle, vas deferens, or ejaculatory duct.

The fundamental difference between females and males:

- ***In females***, ectopic ureters can terminate at a level distal to the continence mechanisms of the bladder neck and external sphincter and thus may be associated with ***incontinence.***

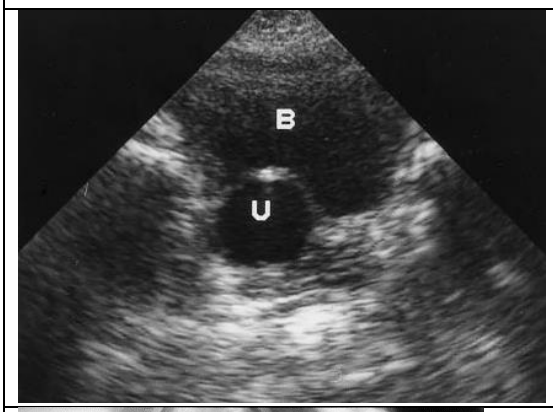
D- Ureterocele

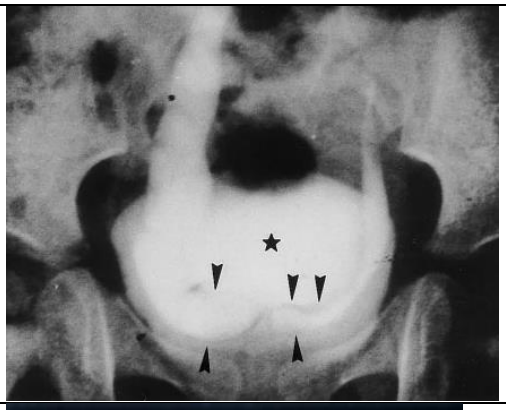
- Cystic dilatation of the intravesical segment of the ureter.

- Ureteroceles may be associated with either a single or a duplex ureter.
- Ureteroceles may be simple or ectopic.

Imaging findings:

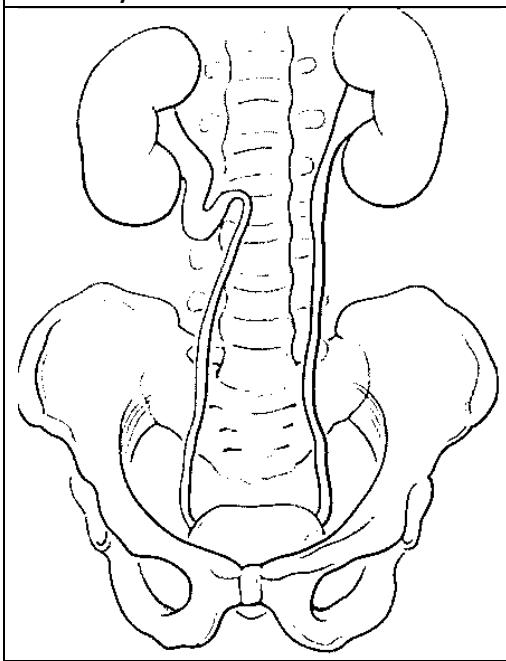
- US: the ureterocele is identified as a cystic intravesical mass, contiguous with a dilated ureter and arising from a normally positioned ureteral orifice near the lateral margin of the trigone.
- ***IVU: "cobra head"*** = round or oval area of collection of contrast material within the ureterocele, surrounded by the radiolucent halo of the wall of the ureterocele

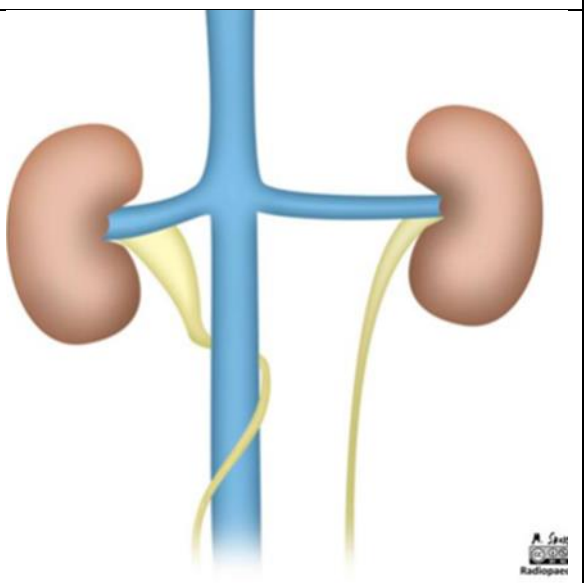


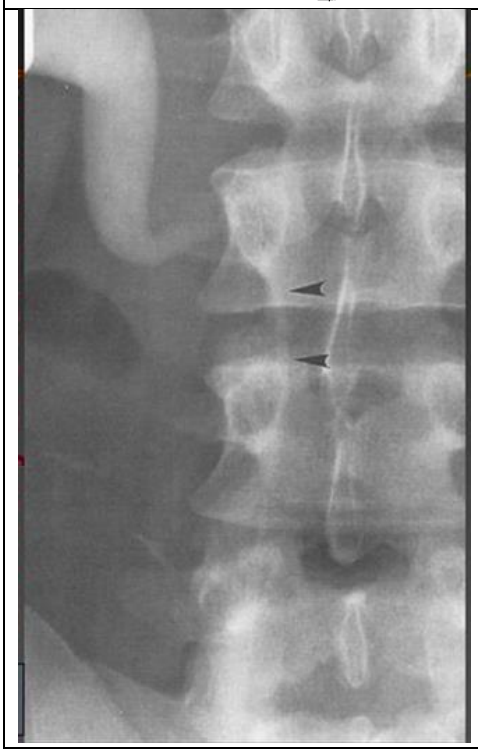


E-Retrocaval Ureter / Circumcaval Ureter

- Ureter passes behind IVC and exits between aorta and IVC.
- May result in ureteric obstruction.







Differential Diagnosis

Medial displacement of upper ureter:

- Retrocaval ureter
- Retroperitoneal fibrosis

Lateral displacement of upper ureter:

- Retroperitoneal mass
- Retroperitoneal lymphadenopathy
- Retroperitoneal hematoma
- Abdominal aortic aneurysm

❖Ureter Filling Defect

- Within the lumen
  - Stones
  - Blood clots (>50 HU; not enhance)
  - Sloughed papilla
- From wall:
  - Transitional cell carcinoma (TCC)
  - Ureteritis cystica
  - Malacoplakia
  - Leukoplakia
  - Endometriosis
- From outside:
  - Vascular indentations
  - Mass effect

❖ Hydroureter:

Typically unilateral:

- Within the lumen
  - Stones
  - Blood clots
  - Sloughed papilla
- From wall:
  - Transitional cell carcinoma (TCC)
  - Ureteritis cystica
  - Malacoplakia
  - Leukoplakia
  - Endometriosis
  - Stricture
- Extrinsic compression
  - Vascular indentations
  - Mass effect
- Residual dilatation from a previously resolved obstruction (particularly if the distention was severe)

Unilateral or bilateral Congenital Abnormality:

- Vesicoureteral reflux
- Primary megaureter (>7mm dilatation)
- Ectopic ureter
- Ureterocele
- Prune belly syndrome (bilateral)

Bilateral:

- Polyuria or diuresis (eg, medication, diabetes insipidus)
- Bladder outlet obstruction
- Neurogenic bladder
- Pregnancy (more pronounced on right side)

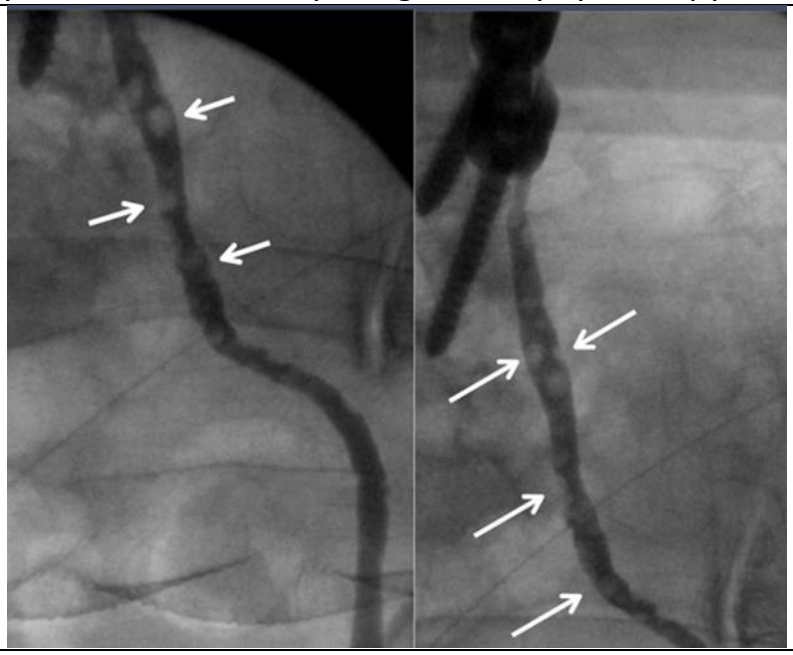
Ureteritis Cystica

- Rare and benign condition of the ureter and sometimes renal pelvis (**pyeloureteritis cystica**) resulting from multiple fluid-containing submucosal cysts
- Associated with chronic inflammation and diabetics with chronic and recurring urinary tract infections
- Also associated with nephrolithiasis and chronic obstruction
- Cysts result from degeneration of epithelial cells

- Age: 50-60 years of age
- Bilateral in up to 50% of cases

Imaging Findings

- Multiple 2-5 mm filling defects
- Rounded lucencies in the contrast-filled lumen
- Produce scalloping of the margins of the ureter when viewed in profile
- Cystitis cystica is almost always diagnosed by cystoscopy



Ureteric TCC

- Transitional cell carcinoma arises from the urothelium.
- 85-90% of all uroepithelial tumors

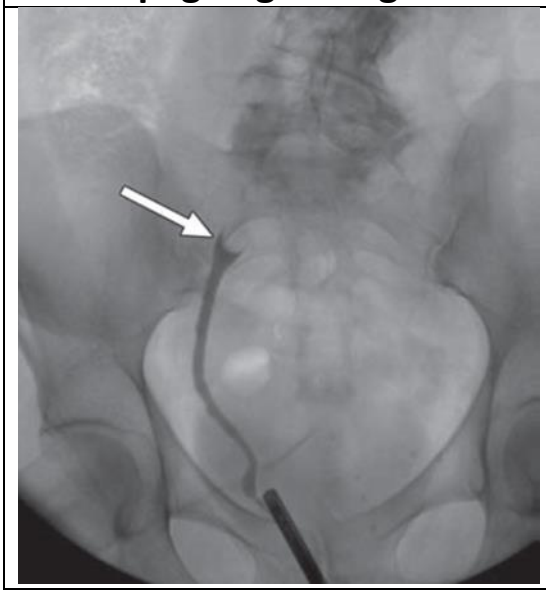
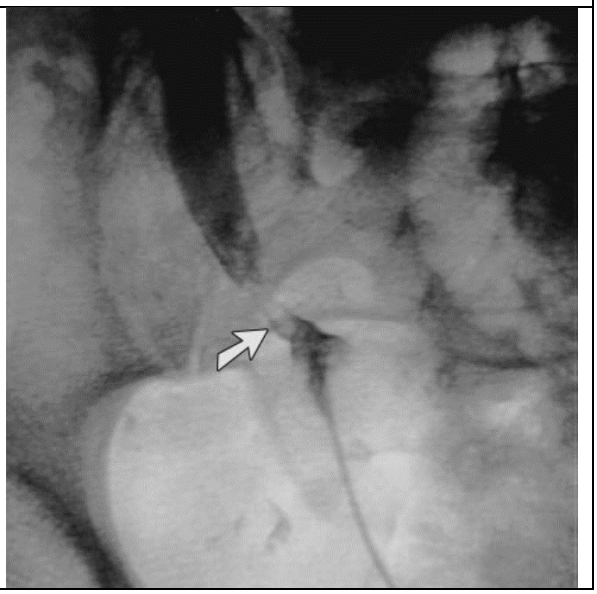
- Age: >60 years.
- Sex: M>>>F by 3 times.

Location of Urothelial Tumors

- 95% UB
- 5% Upper urinary tract
    - 75% Renal pelvis / calices
    - 25% Ureter

Risk Factors

- Smoking (most important risk factor)
- Chemical carcinogens (aniline, benzidine, aromatic amine, azo dyes).
- Cyclophosphamide therapy.
- heavy caffeine consumption.
- Analgesic abuse.

Retrograde Pyelogram "Goblet sign" or "Champagne glass sign"	**Irregular Ureteric Stricture + Proximal Hydroureter**
	

CTUT findings:

- Ureteric wall thickening (eccentric or circumferential),
- Luminal narrowing
- Infiltrating mass
- A thickened enhancing ureteric wall with periureteric fat stranding is suggestive of extramural spread

Ureteric filling defect + Hydronephrosis

Thickened Enhancing Ureteric Wall + Periureteric Fat Stranding

❖ Ureteral Narrowing

Normal ureter:

- Incomplete opacification
- Normal anatomic narrowing at the UPJ, pelvic brim, or UVJ
- Abrupt turn or kink

Ureteric Stricture:

- Iatrogenic:
  - Surgery (eg, gynecologic)
  - Ureteroscopy
- Inflammation from a passed stone
- Tumor (infiltrating TCC or hematogenous metastasis)
- Radiation therapy
- Infection (eg, tuberculosis, schistosomiasis)

Extrinsic causes:

- Adjacent inflammation:
  - Diverticulitis
  - Inflammatory bowel disease
  - Infection
- Retroperitoneal fibrosis
- Encasement by an adjacent tumor (eg, cervix, colon, lymphoma, retroperitoneal metastasis)

Ureteral Pseudodiverticulosis

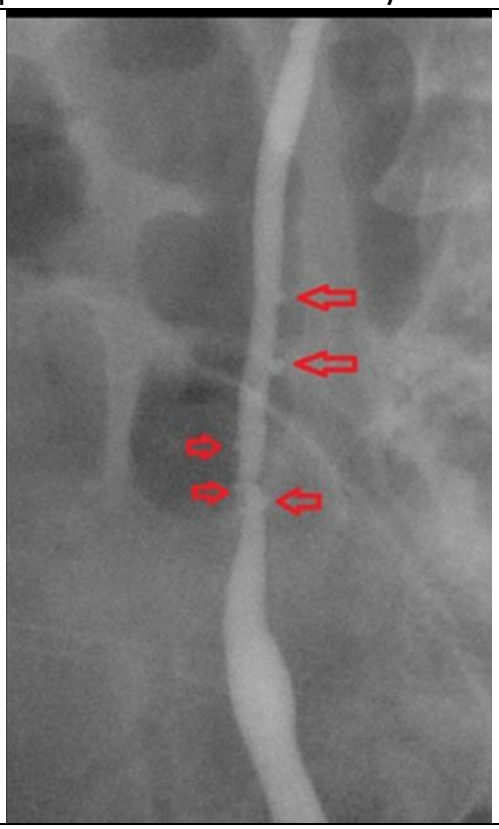
- is acquired false diverticula resulting from herniation of epithelium through the muscularis layer of the ureter

- The etiology and clinical significance of ureteral pseudodiverticulosis are not clear, but chronic inflammation and/or obstruction are likely causes

- An association between the presence of ureteral pseudodiverticula and transitional cell carcinoma has been proposed but not confirmed yet.

Characterized by:

- Multiple small outpouchings < 5mm.
- Commonly bilateral
- Located in the upper two-thirds of the ureter



❖ Surgical Urinary Diversion

Type of Diversion	Relevant Anatomy and Function
Ileal conduit	Loop of ileum disconnected from the gastrointestinal tract and reconstructed into a conduit that diverts urine to the skin; ureters anastomosed to an ileal loop; urine leaks continuously through a stoma
Continent cutaneous diversion	Continent pouch created from detubularized bowel loops; ureters anastomosed to pouch; pouch diverts to skin; pouch must be catheterized regularly via ostomy
Orthotopic neobladder	Continent pouch created at location of patient's urinary bladder from detubularized bowel loops; ureters anastomosed to pouch; pouch connected to native urethra and relies on external sphincter for continence

Urinary System

Urinary Bladder

Urinary Bladder Anatomy

- **Site:** Pelvic extra-peritoneal fat
- **Shape: Pyramidal shape:**
  - Base = Posterior wall
  - Apex = Anterior
  - Dome = Superior wall
  - Trigone = Posterior wall between corners of 2 ureterovesical junctions and the urethra
  - 2 inferolateral walls
  - Neck = Inferior urethral orifice
  - Ureteric orifices = superolateral angles

Arterial supply

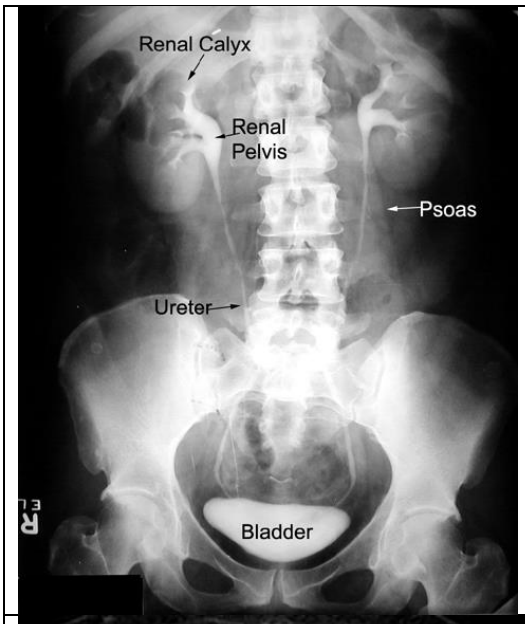
- Superior and inferior vesical arteries (from anterior division of internal iliac artery)

Venous drainage

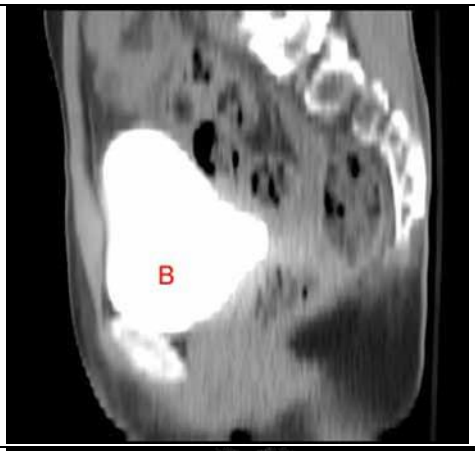
- Male: vesical and prostatic venous plexus via similarly named veins to the internal iliac veins and internal vertebral veins
- Female: vesical and uterovaginal plexuses draining into the internal iliac vein

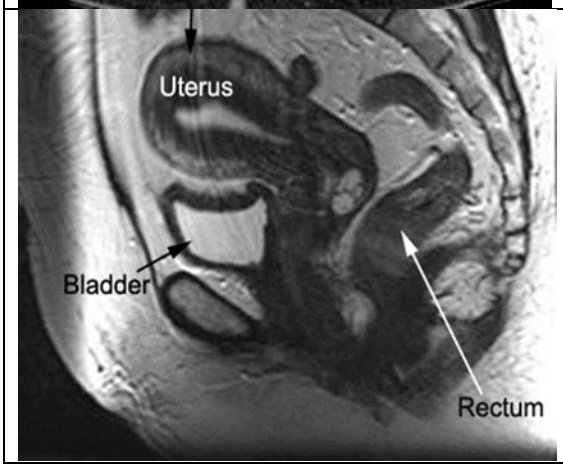
Lymphatic drainage

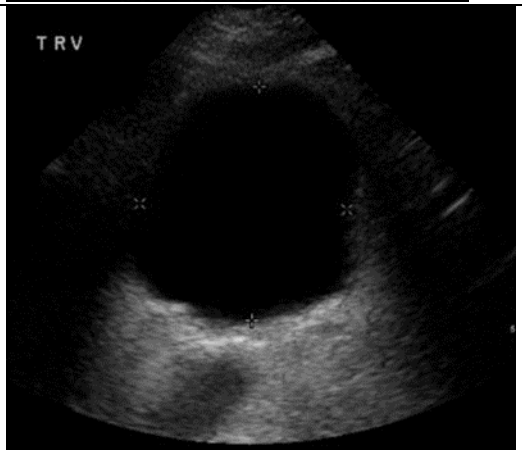
- Internal iliac lymph and para-aortic nodes


Renal Calyx
Renal Pelvis
Psoas
Ureter
Bladder

B


B


Uterus
Bladder
Rectum


TRV

❖ Histology:

4 layers of the bladder wall:

a) Urothelium: which lines the bladder lumen.
b) Lamina propria (submucosa): highly vascular
c) Muscularis propria: referred to as the detrusor muscle and consists of a complex network of interlacing smooth muscle fibers.
d) Serosa: the outermost layer formed by a loose layer of connective tissue

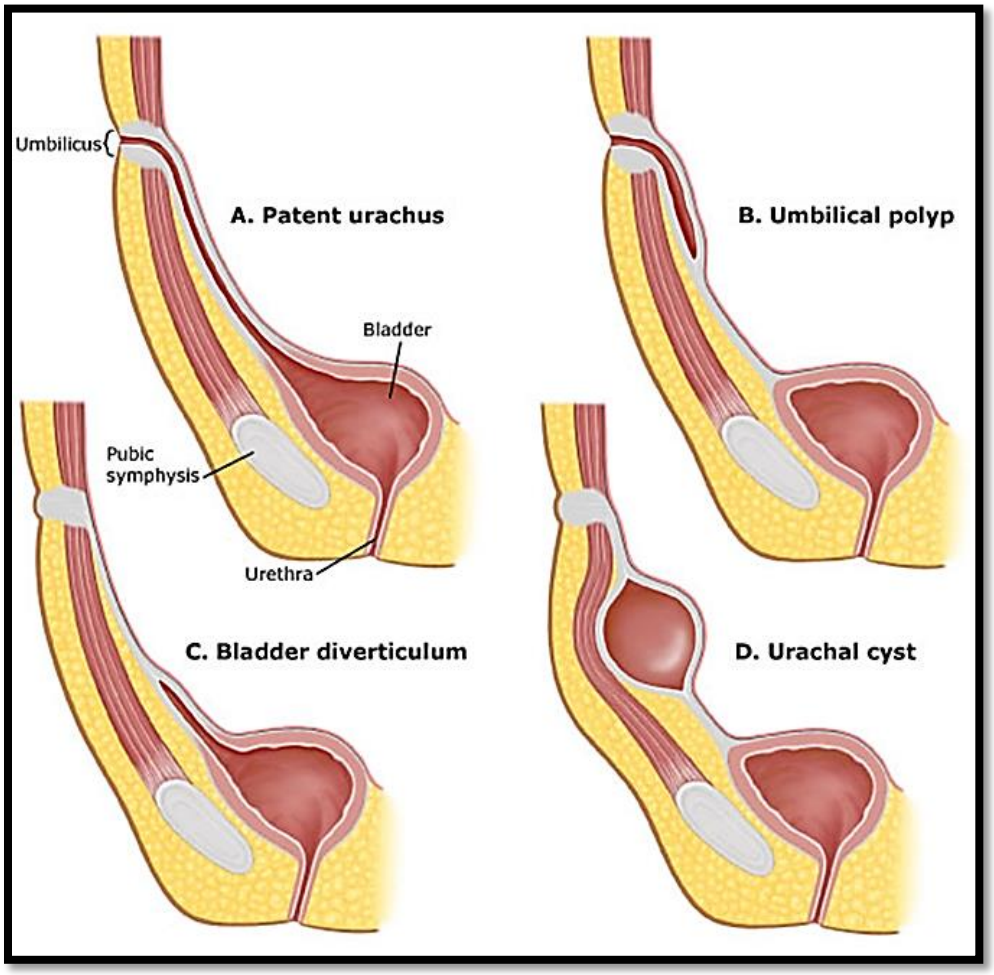
❖ High-Resolution FSE T2 WI:

a) The urine has high signal intensity
b) The bladder wall has low signal intensity.
c) The detrusor muscle appears as a hypointense line.
d) The tumor has intermediate signal that is mildly brighter than the dark bladder wall muscle and lower than the high-signal urine

UB Congenital Anomalies

❖ Urachal Anomalies

- The urachus develops from the superior portion of the urogenital sinus and connects the dome of the bladder to the allantoic duct during fetal life.
- The urachus is located behind the abdominal wall and anterior to the peritoneum in the space of Retzius.
- Before birth, the urachus is obliterated and becomes a vestigial structure known as the medial umbilical ligament.



A) Patent Urachus

- Failure of the entire course of the urachus to close.
- An open channel between the bladder and the umbilicus
- Neonate with urine leaking from the umbilicus.

- This anomaly is demonstrated by
  - Retrograde injection of contrast material into the orifice of the channel at the umbilical end
  - VCUG in the lateral projection.

B) Urachal Cyst

- forms when both the umbilical and vesical ends of the urachal lumen close while an intervening portion remains patent and fluid filled.

- Collection of simple fluid
- Midline deep to the anterior abdominal wall
- Between the umbilicus and the pubis
- Often contiguous with the bladder dome.

C) Umbilical - Urachal Sinus

- is a noncommunicating dilatation of the urachus at the umbilical end.

D) Vesico - Urachal Diverticulum

- a result of the failure of the urachus to close at the urinary bladder, forming an out-pouching of variable length from the anterosuperior aspect of the urinary bladder, which does not communicate with the umbilicus

E)Urachal Infection

• Clinical features: Pain, fever, urinary symptoms

Imaging findings:

- Midline cystic mass with internal echoes and thickened wall
- Inflammatory thickening of urachal cyst/diverticulum
- Peripheral inflammatory stranding

Infected urachal sinus	Infected urachal diverticulum

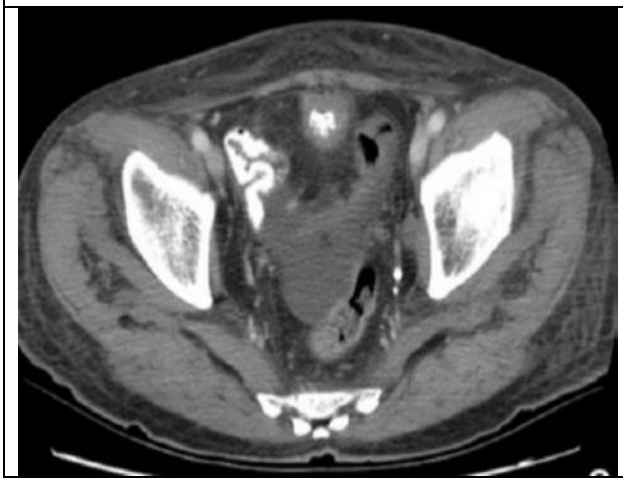
F)Urachal Malignant Tumor

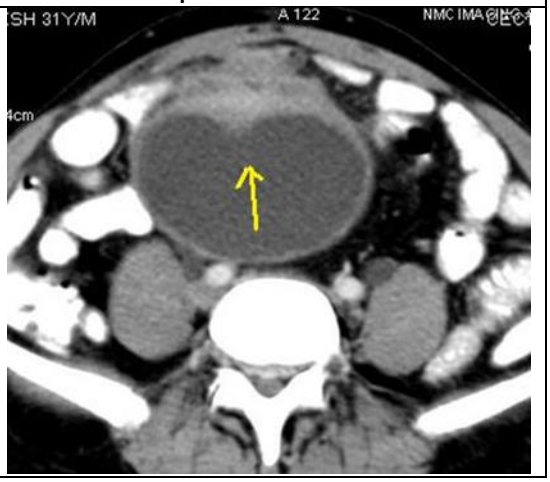
- Incidence: 0.01% of all adult malignancies
- 0.17 to 0.34% of bladder carcinoma
- Adeno-carcinoma is most common urachal carcinoma.

- Clinical features: Supra pubic mass, hematuria, dysuria

Imaging findings:

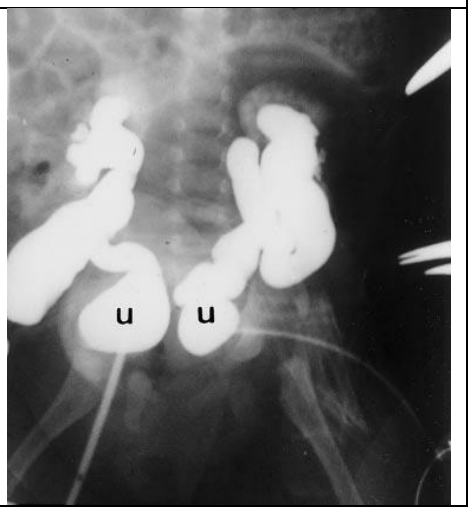
- Complex solid/cystic mass
- Asymmetric midline thickening/mass of bladder dome
- 60% Focal regions of low attenuation-mucin content
- 50-70% Punctate, stippled, curvilinear or peripheral calcification
- 95% Muscle invasion or metastasis at the time of presentation





❖ Bladder Agenesis

- Extremely rare congenital anomaly
- Ectopic ureteric openings

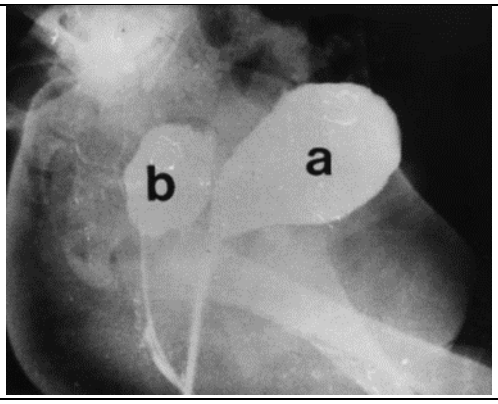


❖ Bladder Duplication

- Complete duplication of the bladder and urethra is a rare anomaly.
- Duplication of the bladder may occur in the sagittal or coronal plane.

Sagittal bladder duplication:	**Coronal bladder duplication:**
• The most common form • Two bladders lie side by side and are separated by a fold of peritoneum and loose areolar tissue.	• is much more unusual. • Two bladders lying one in front of the other and separated by a fibromuscular septum

- Each bladder receives the ureter of the ipsilateral kidney and is drained by its own urethra.



❖ Bladder Diverticulum

Hutch diverticulum

- A diverticulum that occurs at the ureterovesicular junction is usually called periureteric diverticulum and is often associated with VUR.

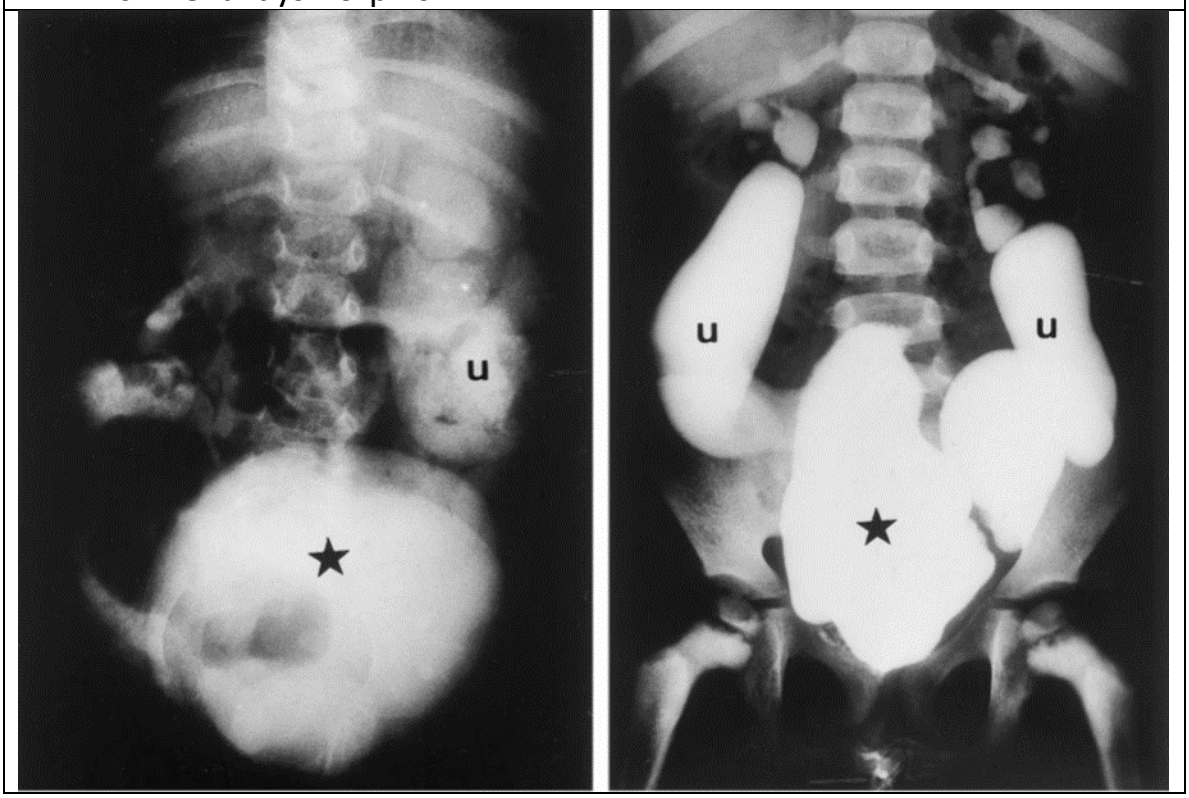
Differential Diagnosis: Bladder ears:

- Protrusion of the urinary bladder anteriorly through inguinal ring
- More often seen in children than adults
- Seen most often when bladder is maximally distended Will empty when bladder is emptied (diverticula tend to fill when bladder is emptied)
- Transient and usually disappear with age.

❖ Prune-Belly Syndrome =
❖ Eagle-Barrett syndrome

Triad of:

- Distended and lax abdominal wall that results from the absence of rectus muscles.
- Cryptorchidism = Bilateral, nonpalpable undescended testes
- Abnormal urinary tract characterized by:
    - Marked bilateral hydroureter and hydronephrosis
    - Large floppy bladder
    - Dilated prostatic urethra
    - Renal dysmorphism



❖ Cloacal Malformation

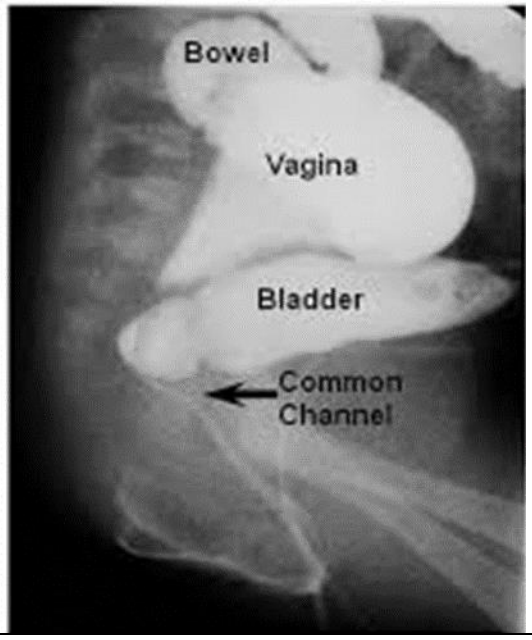
- The urinary, genital, and distal gastrointestinal tracts empty into a common channel called the cloaca in the 3- to 5-week-old embryo

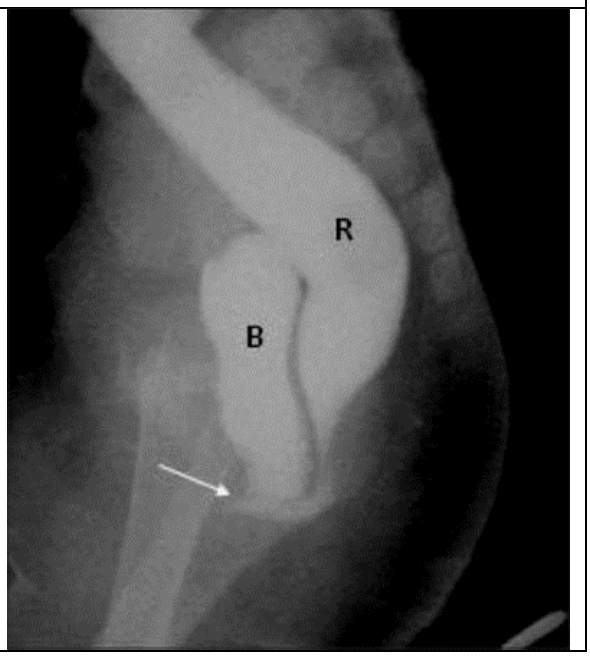
- By the 6th gestational week: the cloaca is segregated into an anterior urogenital sinus and a posterior intestinal canal by the cranial-to-caudal descent of the urorectal septum.
- The caudal extension of the urorectal septum develops into the perineal body, dividing the perineum into:
  - ***Urogenital triangle ventrally***
  - ***Anal triangle dorsally***

- Cloacal malformation represents persistence of an early embryonic state and failure of the urorectal septum to join the cloacal membrane during the 4th to 6th week of embryonic life
  - Urinary tract
  - Genital tract
  - GIT tract

  } All drain through common perineal opening

- Contrast material–enhanced studies of the cloaca and the distal end of the colostomy with fluoroscopy in various projections are essential for diagnosis.

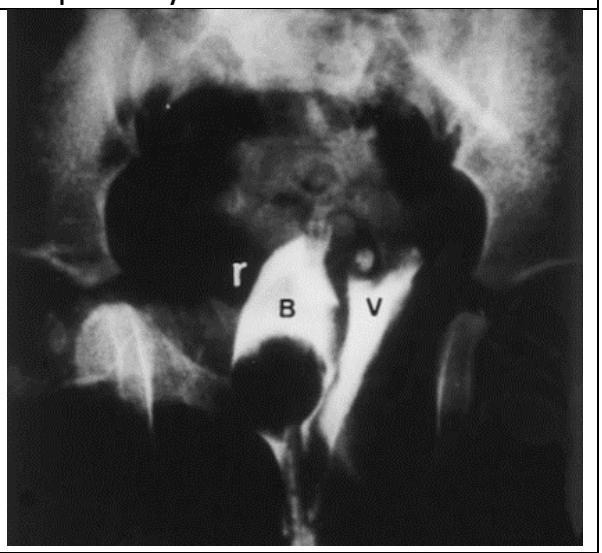




❖ Persistent Urogenital sinus

- The urinary and genital tracts drain through a common perineal opening but the gastrointestinal tract drains separately.

- ***2 perineal orifices:***
  - The anterior orifice for the bladder and vagina
  - The posterior anal orifice
- VCUG image through the anterior perineal orifice shows the bladder (B) and vagina (V



❖ Cloacal Exstrophy

- Exstrophy of the cloaca is seen in both boys and girls

Consists of:

→ **Exstrophy of the bladder**

→ **Omphalocoele**

→ **Lower abdominal wall defect**

Serological markers

- Raised maternal alpha fetoprotein levels

Imaging findings:

- Absence of a normal urinary bladder
- Low-lying umbilical cord insertion
- soft-tissue mass extending from a large infra-umbilical anterior wall defect
- Failure of the pubic bones to meet in the midline (widened pubic symphysis).

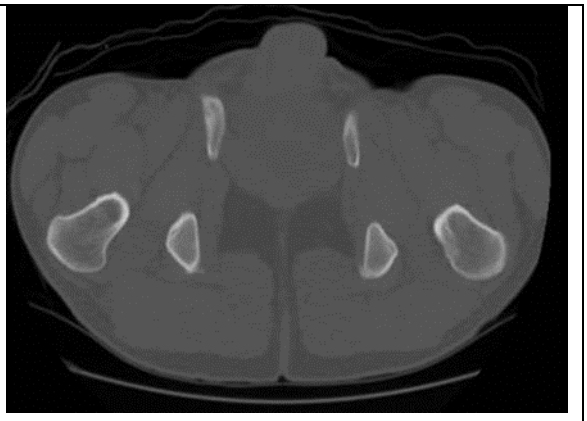
Associations

General

- Extension of the bladder defect into the urethra
- cryptorchidism
- bilateral inguinal herniation
- OEIS complex
- Epispadia
- Vertebral anomalies
- Limb anomalies
- Myelomeningocoele

In females

- vaginal duplication
- clitoral cleft



Differential Diagnosis
Bladder Wall Thickening

- ✓ **>3 mm when distended**
- ✓ **>5 mm when nondistended**

Diffuse bladder wall thickening

- Infectious cystitis
- Cystitis from radiation or chemotherapy
- Bladder outlet obstruction
- Neurogenic bladder

Focal bladder wall thickening

- Urothelial cell carcinoma of the bladder (transitional cell carcinoma)
- Other bladder neoplasm
    - Squamous cell carcinoma of the bladder
    - Adenocarcinoma of the bladder
    - Bladder lymphoma
    - Small cell bladder tumour
    - Bladder paraganglioma
    - Bladder wall leiomyoma
- Artifact: blood products / clot: not enhance on postcontrast CT or MRI; no vascularity on colour Doppler
- Cystitis: more commonly diffuse than focal, but may mimic neoplasm adjacent inflammatory process (e.g. diverticulitis)
- Cystitis cystica and cystitis glandularis
- Amyloidosis of the bladder: rare
- Malacoplakia of the bladder: rare

Cystitis

A- Bacterial Cystitis

Causative organism:

- ***E. coli*** is the most commonly encountered organism,
- Other common agents include species of Staphylococcus, Streptococcus, Proteus, Pseudomonas, Aerobacter.

Route of infection:

- Ascending rout from urethra

Predisposing factors:

- Bladder mucosa has been damaged by trauma, stone, or tumor
- Bladder outlet obstruction prevents bacteria from being completely washed out;
- Bladder catheterization or instrumentation introduces infection by bypassing the protective mechanisms of the urethra and prostate.

Role of imaging:

- Recurrence of acute cystitis and cases that are resistant to antibiotic therapy suggest an underlying cause.
- In such cases, imaging of the entire urinary tract and cystoscopic evaluation of the bladder are indicated to exclude causes such as urinary stone disease, bladder diverticulum, colovesical fistula, and perivesical abscess.

B- Emphysematous Cystitis

- Acute inflammation of bladder mucosa and underlying muscle with gas forming organism.

Risk factors

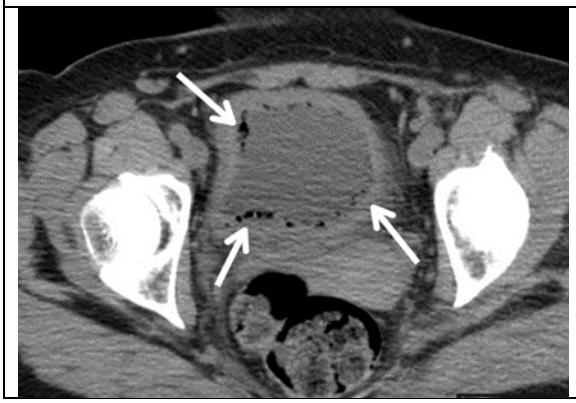
- Diabetes mellitus: commonest predisposing factor
- Immunocompromised state
- Neurogenic bladder
- Transplant recipients

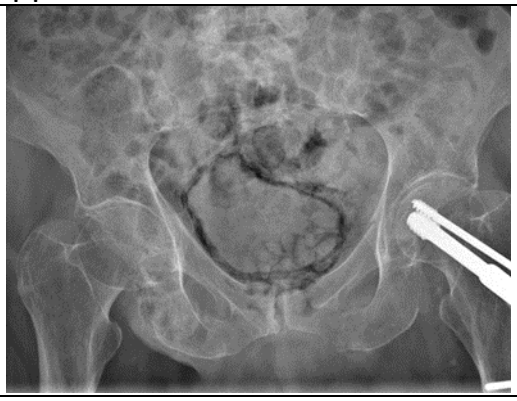
Causative organism:

- The most common causative organism is E. coli
- other organisms including Enterobacter aerogenes, Klebsiella pneumonia, Proteus mirabilis, Staphylococcus aureus, streptococci, Clostridium perfringens and Candida albicans.

Imaging findings:

- intramural air: curvilinear or mottled areas of air, separate from more posterior rectal gas.
- Intraluminal gas: Air-fluid level that changes with patient position, and, when adjacent to the nondependent mucosal surface, may have a cobblestone or “beaded necklace” appearance





C- Tuberculosis Cystitis

- Tuberculosis of the bladder is an uncommon bladder disease in Western countries.

Causative Organism:

- Mycobacterium tuberculosis
- or less often from Bacillus Calmette-Guerin (BCG) treatment for urothelial carcinoma

Rout of infection:

- Tuberculosis of the urinary tract almost always begins in the upper tracts, with the bladder being secondarily involved.

Predisposing factors:

- Immunocompromised patients with acquired immunodeficiency syndrome or recipients of organ transplants are also at higher risk

Cystoscopy:

- Early features of bladder tuberculosis are cystitis with a thick, chalky, white mucosa, mucosal ulceration; and edema.
- Later, fibrosis causes a contracted bladder
- Biopsy is caseating granulomas
- Positive Ziehl-Neelsen stain.

Imaging findings:

- Irregular mucosal masses due to coalescing tubercles with ulceration and edema, diffuse wall thickening, and trabeculation
- Irregular mural thickening
- Ureteral strictures and thickening with obstruction,
- Fixed and patulous vesicoureteric junction => Vesicoureteric reflux.
- In the chronic phase: thick-walled contracted bladder from fibrosis.
- Urinary bladder calcification is rare.

D- Schistosomiasis

- Bladder schistosomiasis is uncommon in the United States, but it is a major health problem in developing parts of the world, especially Africa,

Causative organism:

- Schistosoma haematobium species

Rout of infection:

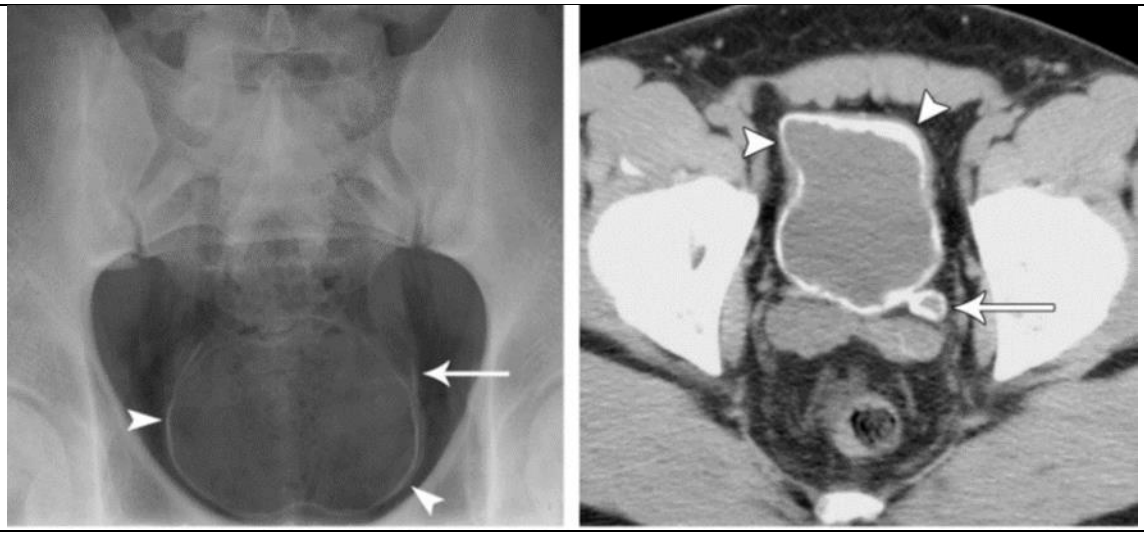
- The larvae (cercariae) are released from snails into water and penetrate human skin exposed to the infected water.

Clinical picture:

- Symptoms are nonspecific and are most commonly dysuria, suprapubic pain, microscopic hematuria, and frequency.

Imaging findings:

- Acute phase: Nodular bladder wall thickening
- Chronic phase: Contracted, fibrotic, thick-walled bladder with calcifications.



E- Cystitis Cystica and Cystitis Glandularis

- Common chronic reactive inflammatory disorders, which occur in the setting of chronic irritation

Metaplasia of the urothelium is incited by irritants such as:

- Chronic bladder outlet obstruction
  - Pelvic lipomatosis
  - Benign prostatic hypertrophy
  - Bladder TCC
- Chronic infection
- Bladder calculi

- Any age with prevalence of children with urinary tract infections

Pathological:

- The urothelium then proliferates into buds (nests of von Brunn), which grow down into the connective tissue beneath the epithelium in the lamina propria. The buds then differentiate into:
  - Fluid filled cysts => Cystitis cystica
  - Intestinal columnar mucin-secreting goblet cells => Cystitis glandularis

Clinical presentation:

- Symptoms are those of chronic irritation, such as frequency, dysuria, urgency, and hematuria

Imaging findings:

- Hypervascular small polypoid mass.
- T2: low signal lesion with central branching hyperintensity.
- Central T2 hyperintensity enhances on contrast administration and represents vascular stalk.
- The muscle layer should be intact, a feature that distinguishes cystitis cystica and cystitis glandularis from urothelial carcinoma.

→ In young patients, their age should raise the suspicion that the lesion might be nonneoplastic.
→ Biopsy is necessary for a definitive diagnosis.
→ These patients should be monitored carefully because of the possible association with adenocarcinoma.

F-Crohn Disease

- Bladder involvement in Crohn disease consists of fistulas from inflamed small and large bowel.
- Crohn disease is the most frequent cause of ***ileo-vesical fistula*** and ***ileocolo-vesical fistula***

- The bladder is secondarily involved by the adjacent bowel inflammatory lesions.
- Transmural inflammation and deep fissures cause fistulas between diseased bowel and other viscera such as the bladder.

Imaging findings:

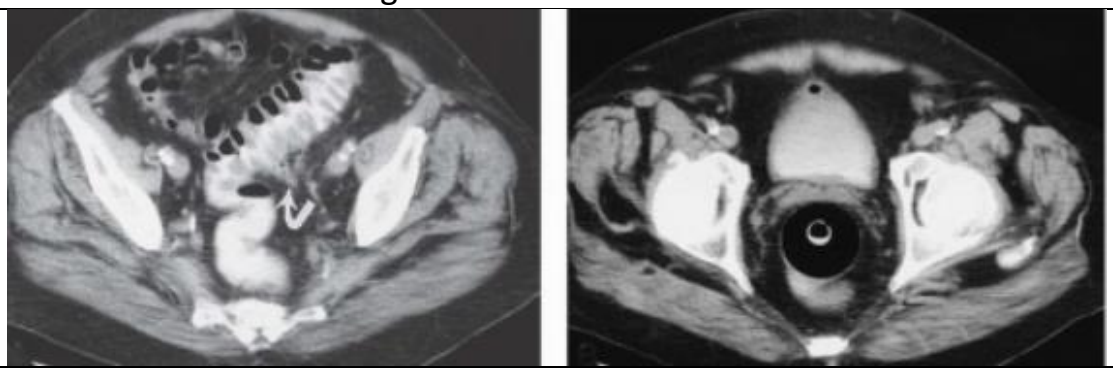
- Air within the bladder
- Focal irregularity of the wall
- Tethering of thickened adjacent bowel
- The presence of orally administered contrast material in the bladder is diagnostic of a fistula between the bowel and bladder.
- Fibrofatty proliferation, infiltration of fat, phlegmon, and lymphadenopathy

G- Diverticulitis

- Colovesical fistulas and cystitis are not uncommon complications of diverticulitis

Imaging findings

- Bladder wall thickening with gas in the bladder lumen
- Adjacent inflamed colon with diverticula
- Pericolonic fat stranding

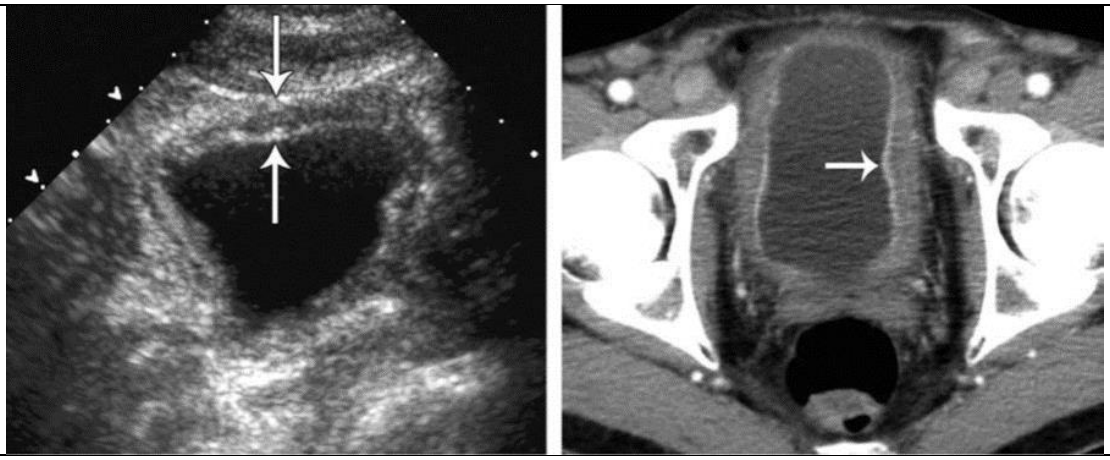


H- Radiation and Chemotherapy Cystitis

- Severe hemorrhagic cystitis may develop after chemotherapy or irradiation of the bladder

Imaging findings:

- Diffuse irregular thickening
- Hypervascularity in the wall and bleeding vessels
- intraluminal clot



Malacoplakia

- Malacoplakia of the urinary tract is an uncommon chronic granulomatous inflammatory disease.
- Malakoplakia (meaning "soft plaque") can affect any organ.

- The disease is common in patients who are immunocompromised or in those with diabetes mellitus or recent transplant recipients

- Sex: F >> M = 4:1
- Age: Middle age

<u>Urinary tract is the most common system involved:</u>

- 40% urinary bladder involvement
- 16% renal involvement

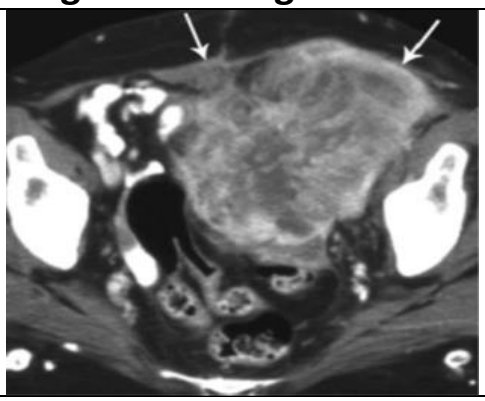
<u>Clinical presentation:</u>

- Gross haematuria
- signs of urinary tract infection, such as hesitancy,
- dysuria, and frequency; with Escherichia coli infection being very commonly found to coexist.

<u>Imaging findings:</u>

- Multiple, polypoid, vascular, solid masses
- Circumferential wall thickening

→ Given the nonspecific cystoscopic and imaging appearances of malacoplakia that may simulate those of neoplasms,
→ Biopsy is essential for appropriate conservative management.

Diffuse mural thickening	**Large enhancing mass**
	

Leukoplakia

- Leukoplakia of the urinary tract is a squamous metaplasia of the urothelium (keratinisation).
- Clinically the condition presents with haematuria in one-third of cases, dysuria, frequency and nocturia, and thus it can mimic cystitis.
- Passage of the desquamated keratinised epithelial layers can also occur.

- The condition is associated with infection in the majority of cases (80%) and calculi in 40%.

Location:

- Bladder > Renal pelvis > ureter

Radiographic features

- Mucosal thickening and multiple filling defects

Bladder Outlet Obstruction (BOO)

Clinical Presentation

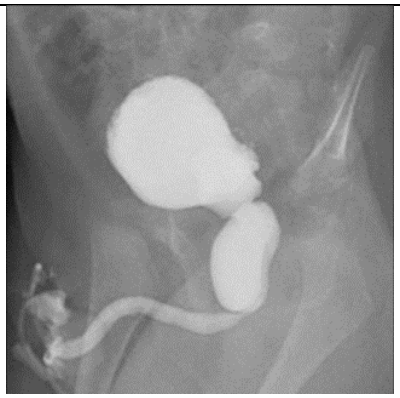
- Difficulty in urination, retention and urinary discomfort

Aetiology:

- Elderly men:
  - BPH
  - Prostatic cancer
- Male infants:
  - Posterior urethral valve
- Young males:
  - Urethral stricture
  - Stones
- Females:
  - Urethral stricture
  - Urethral diverticulum
  - Cystocele
  - Fowler's syndrome (idiopathic urine retention)

Imaging findings:

- Diffuse bladder wall thickened and trabeculated.
- Urinary retention
- Increased post void residual on sonographic or voiding studies

BPH is the most common cause in elderly male	**Posterior urethral valve is the most common cause in male infants**
	

Neurogenic Bladder

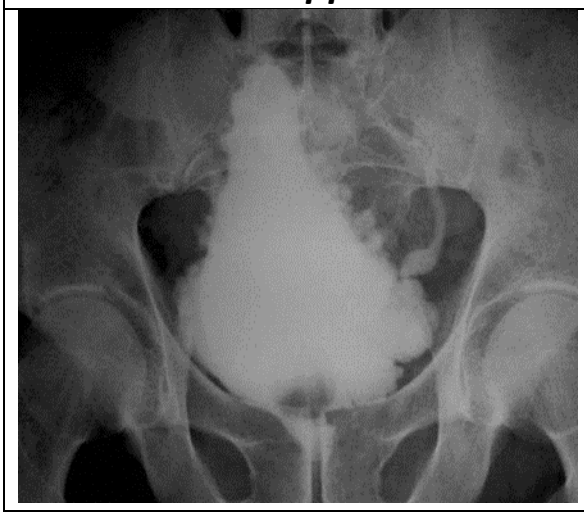
- is a term applied to a dysfunctional urinary bladder that results from an injury to the central or peripheral nerves that control and regulate urination.
- Injury to the brain, brainstem, spinal cord or peripheral nerves from various causes including infection, trauma, malignancy or vascular insult can result in a dysfunctional bladder.

Aetiology:

- Multiple sclerosis: ~17%
- Parkinson disease: ~15%
- Cauda equina syndrome: ~9%
- Paralytic syndrome: ~8%
- Stroke complications: ~6%

Imaging findings under fluoroscopy:

- Large atonic bladder with inability of detrusor contraction during voiding => Motor paralytic bladder
- Small contracted bladder => Hyperreflexia

Christmas tree appearance	*Large atonic bladder*
	

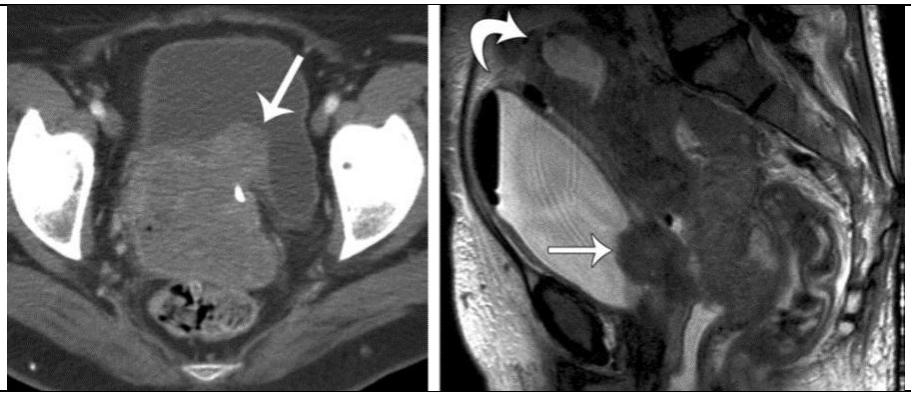
Extrinsic Masses Causing

Bladder Filling Defects

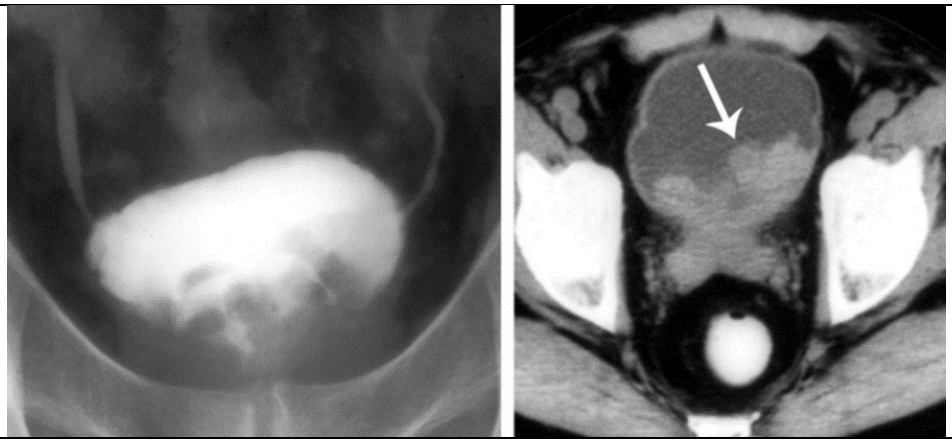
- Prostatic origin
- Uterine origin
- Cervical origin
- Ovarian origin
- Urachal cysts
- Endometriosis
- Hamartomas
- Amyloidosis
- Vascular malformations

❖ **BPH**

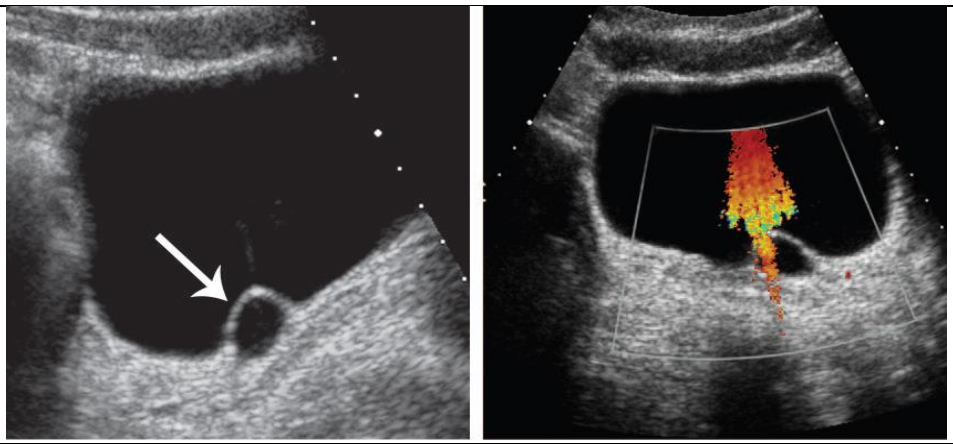
❖ **Cervical cancer**



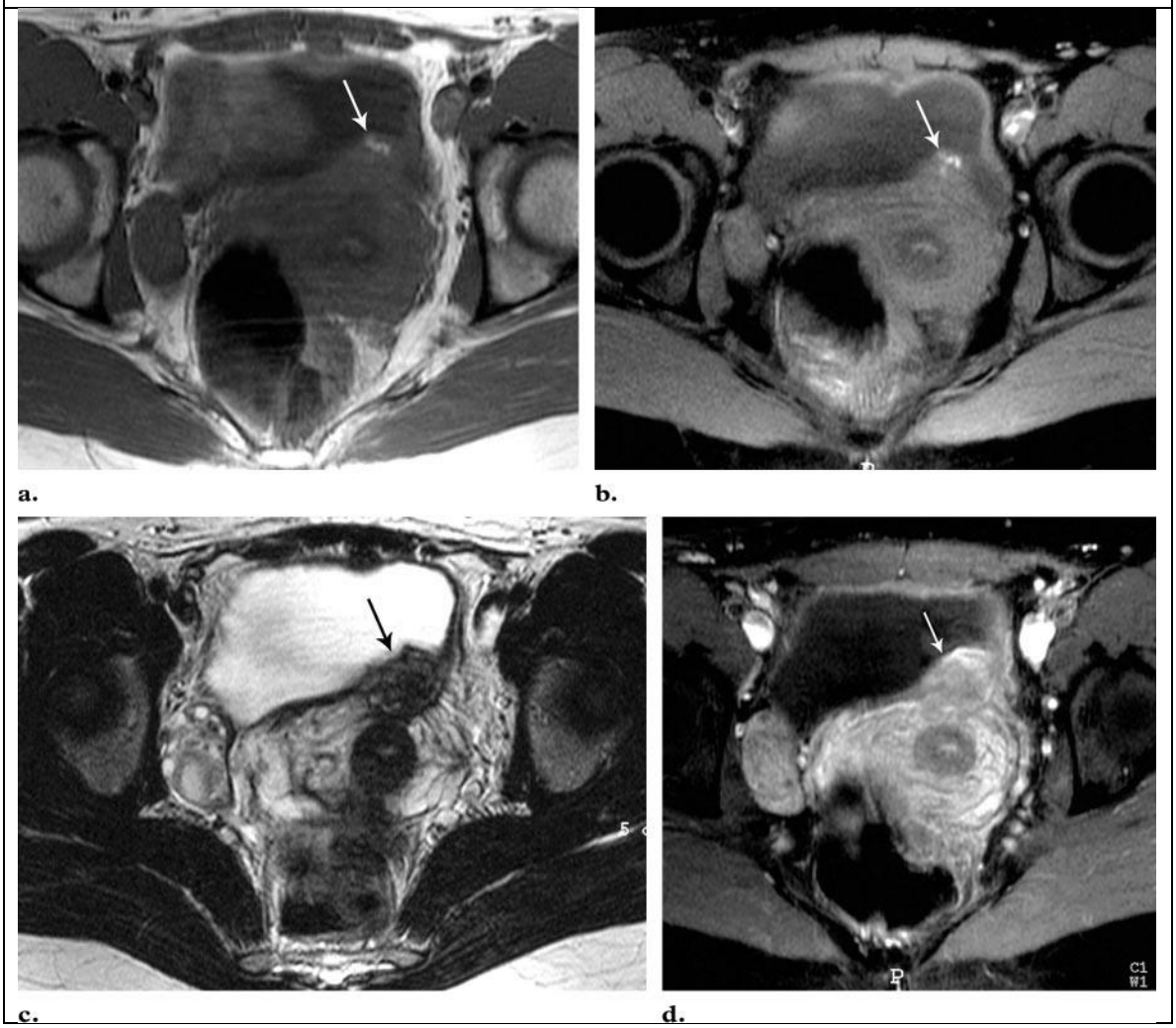
❖ **Prostatic Cancer**



❖ **Ureterocele**



❖ Endometriosis



Urinary Bladder Cancer

- is one of the most common malignancies of the urinary tract,
- 4th most common cancer in males
- 10th most common cancer in females.

- Sex: M>F by 3-4 times
- Age: 50-70y

- Multicentric bladder tumors occur in up to 30%–40% of cases

❖Pathologic Features:

Benign Neoplasms:

Papilloma

PUNLMP = Papillary urothelial neoplasm of low malignant potential

Malignant Neoplasms:

90%: Urothelial carcinoma (ie, transitional cell carcinomas).

6-8%: Squamous cell carcinomas

<2%: Adenocarcinomas are rare and typically represent urachal cancer.

<5%: Mesenchymal tumors

❖Risk Factors For Urothelial Carcinoma

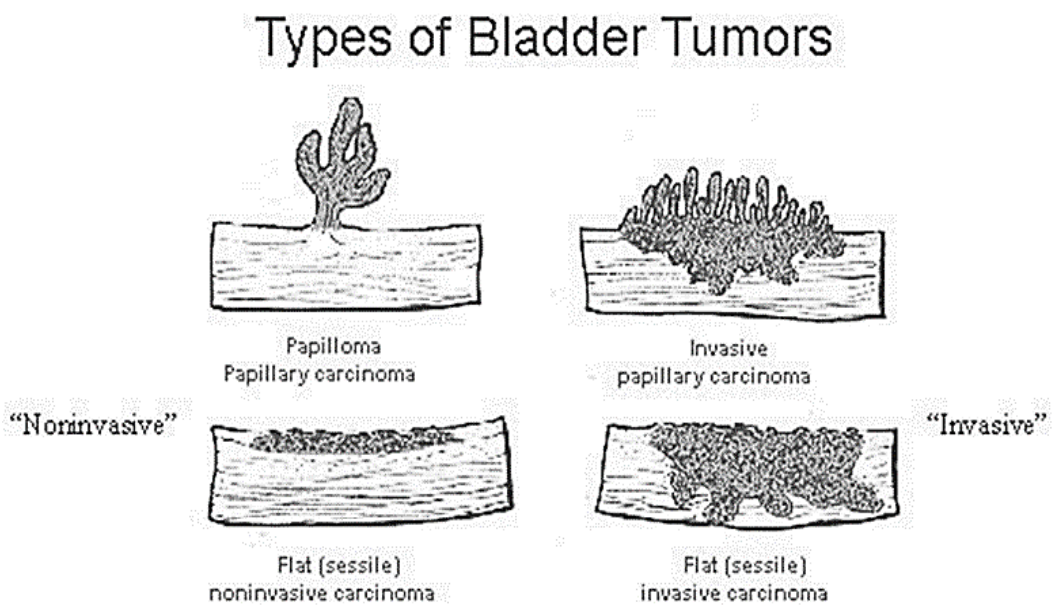
- Occupational exposure to chemical carcinogens such as aniline dyes
- Cigarette smoking is thought to be the causative factor in 50%–60% of men and 30% of women who develop bladder cancer
- Iatrogenic risk factors are therapeutic irradiation of neighboring organs and the use of alkylating agents.
- Bladder diverticula have an increased risk (2%–10%) of developing cancer because of stasis.
- Genetic predisposition to the development of urothelial tumors in some families

❖Risk Factors For Squamous Cell Cancer

- Long-term catheterization
- Nonfunctioning bladder
- Urinary tract calculi
- Chronic infection by Schistosoma hematobium.

❖ TNM Staging of Bladder Cancer

Tumor	
Tx	Primary tumor cannot be evaluated
T0	No primary tumor
Ta	Noninvasive papillary carcinoma
Tis	Carcinoma in situ
T1	Tumor invades connective tissue under the epithelium (surface layer)
T2	Tumor invades muscle
T2a	Superficial muscle affected (inner half)
T2b	Deep muscle affected (outer half)
T3	Tumor invades perivesical fat
T3a	Tumor is detected microscopically
T3b	Extravesical tumor is visible macroscopically
T4	Tumor invades the prostate gland, uterus, vagina, pelvic wall, or abdominal wall
Node	
Nx	Regional lymph nodes cannot be evaluated
N0	No regional lymph node metastasis
N1	Metastasis in a single lymph node <2 cm in size
N2	Metastasis in a single lymph node >2 cm but <5 cm in size, or multiple lymph nodes <5 cm in size
N3	Metastasis in a lymph node >5 cm in size
Metastasis	
Mx	Distant metastasis cannot be evaluated
M0	No distant metastasis
M1	Distant metastasis

Non–Muscle Invasive (Superficial Or Papillary)	Muscle Invasive
Ta, Tis, T1	
	
80%–85% are low-grade lesions can be multifocal arise from a hyperplastic epithelium.	20%–25% arise from severe dysplasia or carcinoma in situ,
generally, have a good prognosis and rarely evolve into an invasive cancer	have a higher histologic grade
TURBT response rates are about 80%, 70% of patients Lesions that carry an increased risk of recurrence are treated with adjuvant intravesical chemotherapy (eg, mitomycin C or gemcitabine) or immunotherapy (with bacille Calmette-Guérin [BCG]).	**Radical cystectomy** extended bilateral lymphadenectomy is required 5-year survival rate 27% for stage T4 disease 66% for stage T2 disease. extent of lymphadenectomy correlates with survival

❖ Role of MRI In Evaluation of Bladder Cancer

→ allow more accurate staging of bladder carcinomas than CT because of its high soft-tissue contrast resolution, which allows clear differentiation between bladder wall layers

→ allows differentiation between muscle-invasive and non-muscle-invasive disease.

Role of T1:

→ The tumor typically has a low-to-intermediate signal intensity that is similar to that of the bladder wall, higher than the dark urine and lower than the bright perivesical fat.

→ Evaluate perivesical fat planes for extravesical tumor infiltration.

→ Pelvic lymphadenopathy.

→ Bone metastases.

Role of T2:

→ The tumor has intermediate signal that is mildly brighter than the dark bladder wall muscle and lower than the high-signal urine.

→ Evaluate the detrusor muscle for tumor depth (T2)

→ Extravesical disease spread (T3)

→ Invasion of the surrounding organs (T4)

Role of Dynamic Contrast Enhancement:

→ In the early phase (20 sec) Tumor demonstrates earlier, and more avid enhancement than normal bladder wall and postbiopsy changes.

→ Determine the depth of tumor penetration into the bladder wall.

→ Differentiate perivesical tumor invasion from post-biopsy change.

→ Define invasion into adjacent organs

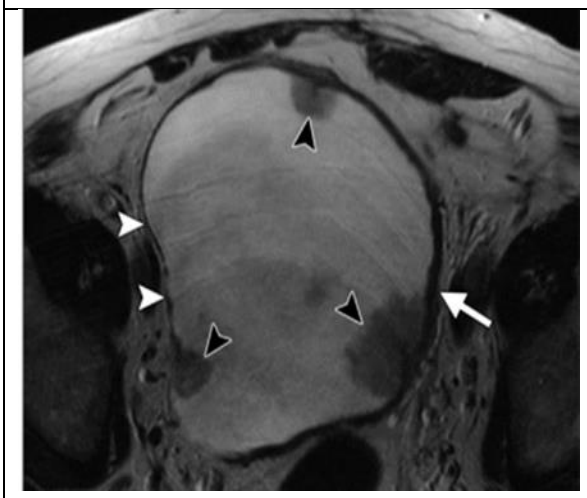
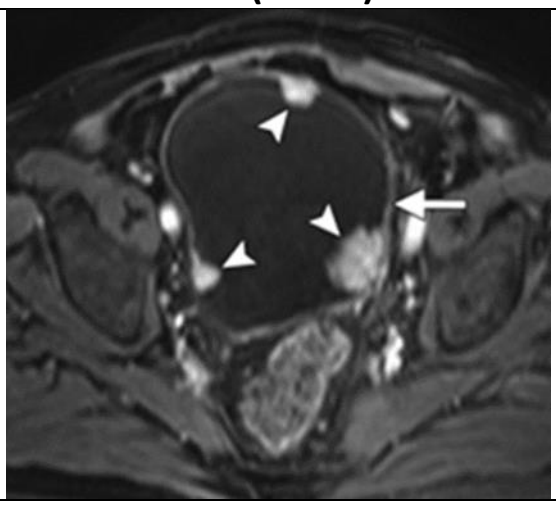
❖ Stage Ta or T1: An intact, low T2 signal intensity muscle layer at the base of the tumor is indicative of nonmuscle invasive bladder tumor.

❖ Stage T2: Muscle invasive tumor is suggested when the normal low T2 signal of bladder wall muscle is interrupted by intermediate T2 tumor signal.

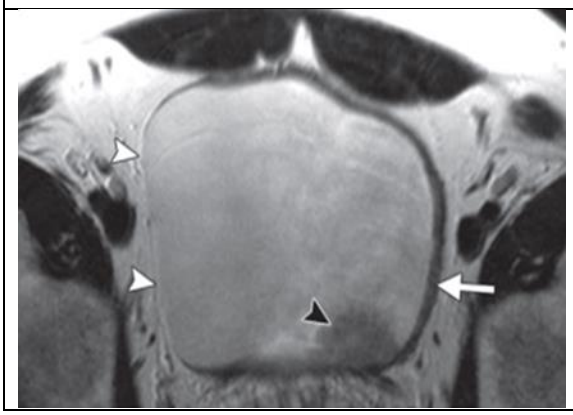
❖ Stage T3a (microscopic perivesical invasion) diagnosis is difficult.

❖ Stage T3b: A bladder wall lesion with an irregular, shaggy outer border and streaky areas of the same signal intensity as the tumor in perivesical fat.

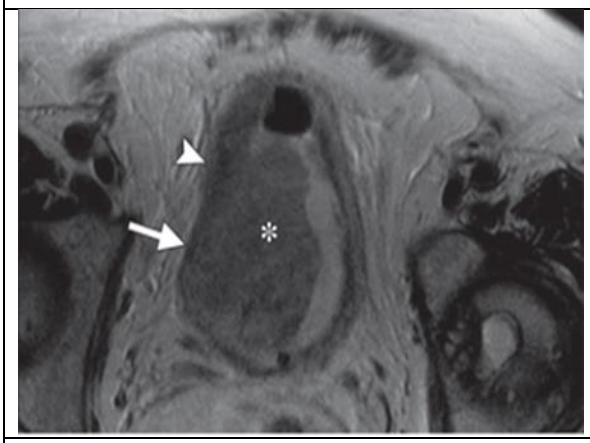
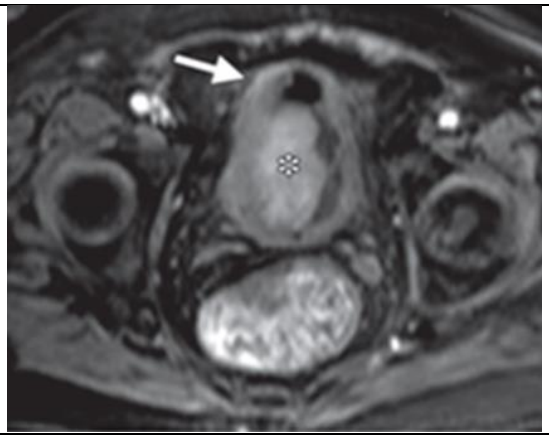
Stage Ta

Multifocal bladder tumors show intermediate T2 signal Low signal muscle layer at the base of the tumor	Multifocal bladder tumors show early intense enhancement. Non-enhancing muscle layer
Axial T2	**Axial T1+C FS (20sec)**
	

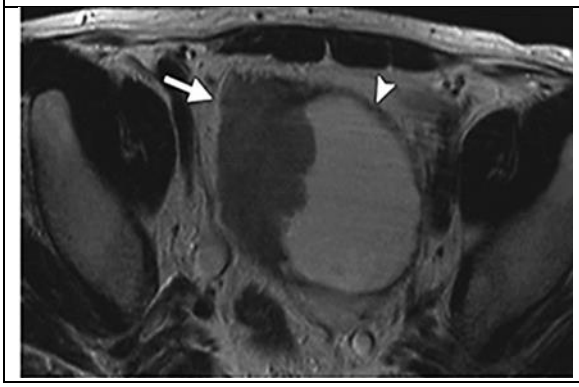
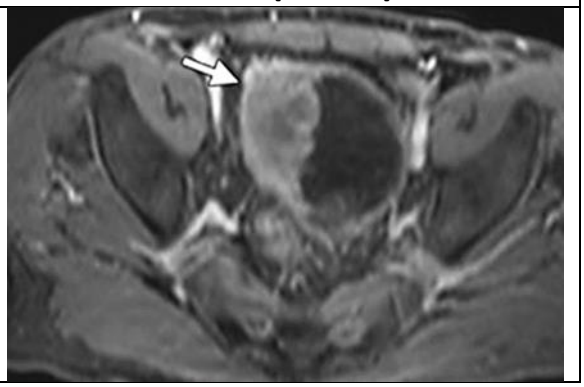
Stage T1:

Axial T2	**Axial T1+C FS (20sec)**
	

Stage T2:

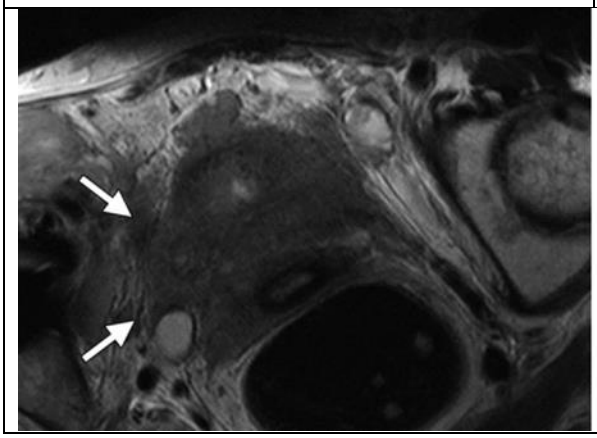
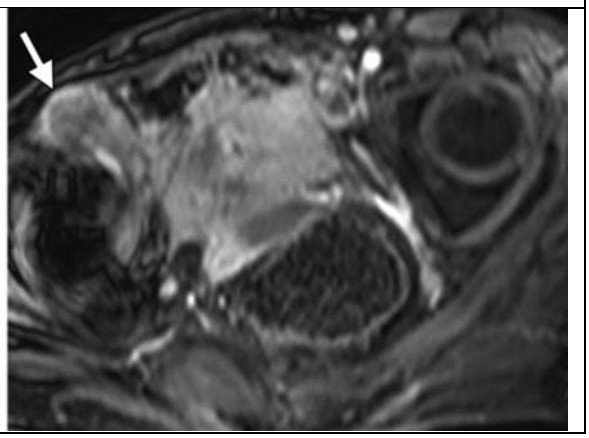
*= intermediate signal of the tumor Arrow = normal low-signal-intensity detrusor muscle Arrowhead = interruption of the detrusor muscle by the tumor	tumor (*), which has enhanced earlier than the muscle layer.
Axial T2	**Axial T1+C FS (20sec)**
	

Stage T3b

Arrow = extravesical mass of intermediate signal Arrowhead = normal low signal of detrusor muscle.	the extravesical enhancing mass (arrow).
Axial T2	**Axial T1 + C FS (60sec)**
	

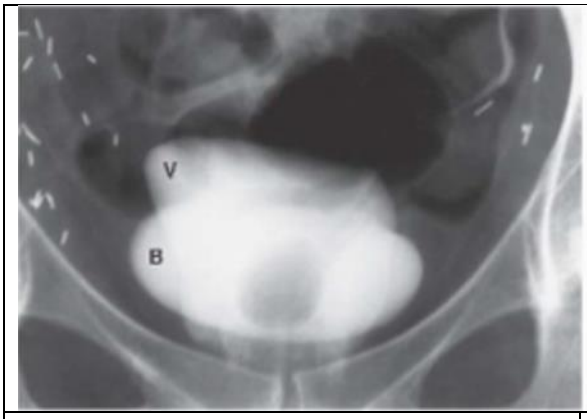
Stage T4:

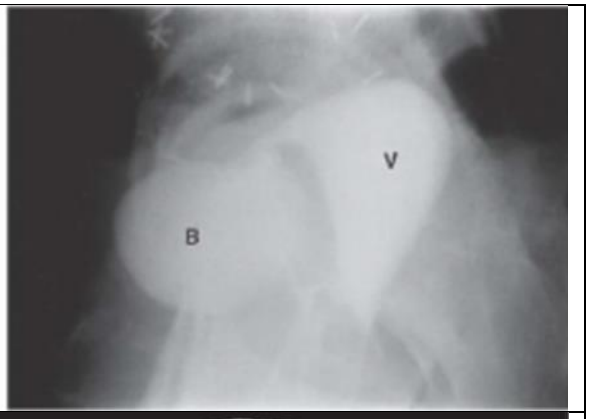
An extravesical mass (arrows) involving the pelvic wall and cervix

Axial T2	Axial T1+C FS
	

Bladder Fistula

❖ COMMON CAUSES OF BLADDER FISTULAE
Enterovesical • Crohn disease
Colovesical • Diverticulitis • Colon carcinoma
Vesicovaginal • Cervical cancer treated with radiation • Post-hysterectomy





Vesicovaginal fistula.
CT urogram, demonstrates excreted contrast material in the posterior aspect of the bladder.
A linear collection of contrast material continues posterior to the bladder to opacify the vagina, confirming the presence of a fistula (arrow).

Urinary Bladder Trauma

5 types of bladder injury:

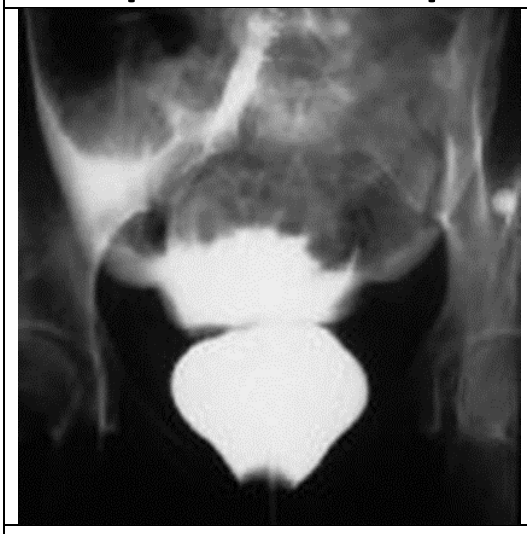
Type 1: Contusion
Type 2: Intraperitoneal Rupture
Type 3: Interstitial Injury
Type 4: Extraperitoneal Rupture
Type 5: Combined Rupture

CT Cystography Technique:

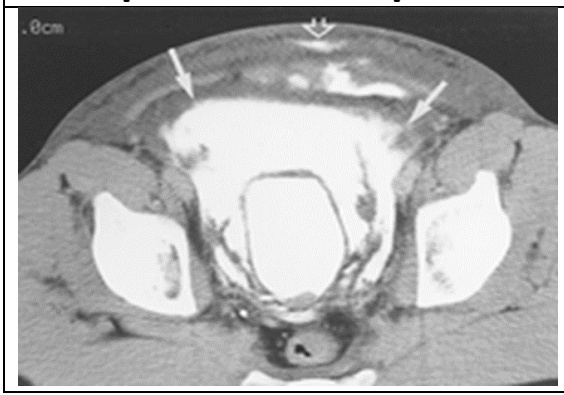
- Instill 300-500ml of diluted contrast material into the urinary bladder
- Clamp bladder catheter for 10-20 min
- Perform abdominopelvic CT

	Extraperitoneal	Intraperitoneal
Mechanism of injury	Shearing or direct laceration	Blunt trauma
CT Cystography	Flame shaped Extravasation of contrast into perivesical soft tissues	Extravasation of contrast around bowel loops and in paracolic gutters
Treatment	Conservative: bladder catheter drainage (superpubic and transurethral)	Aggressive: Prompt open surgical exploration (because risk of urinary peritonitis)

Intraperitoneal Rupture



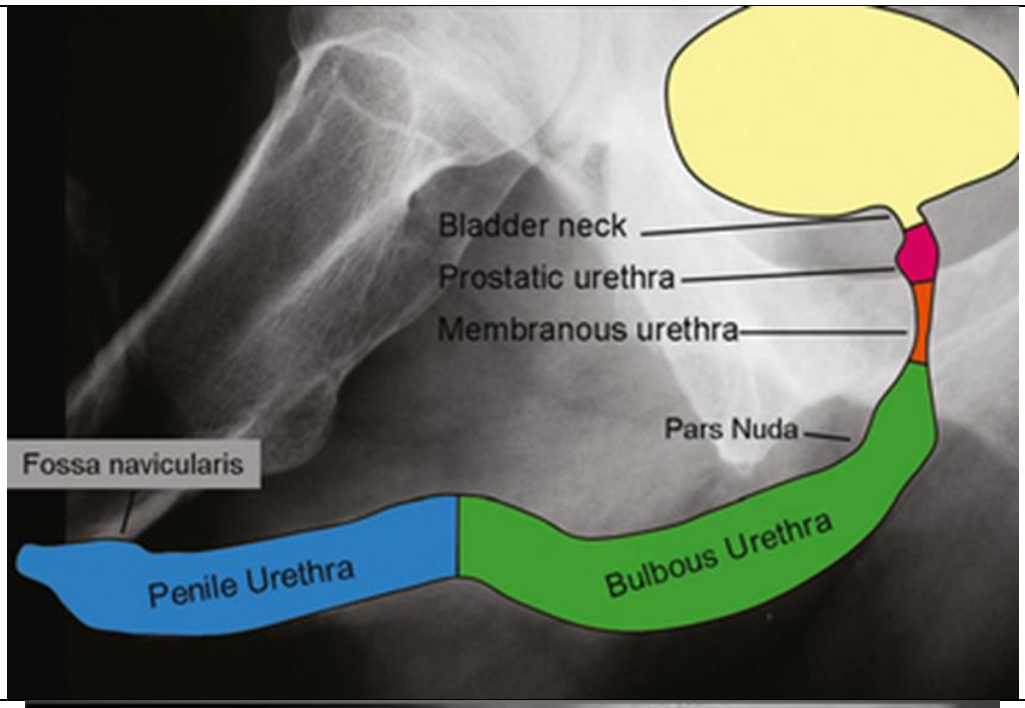
Extraperitoneal Rupture

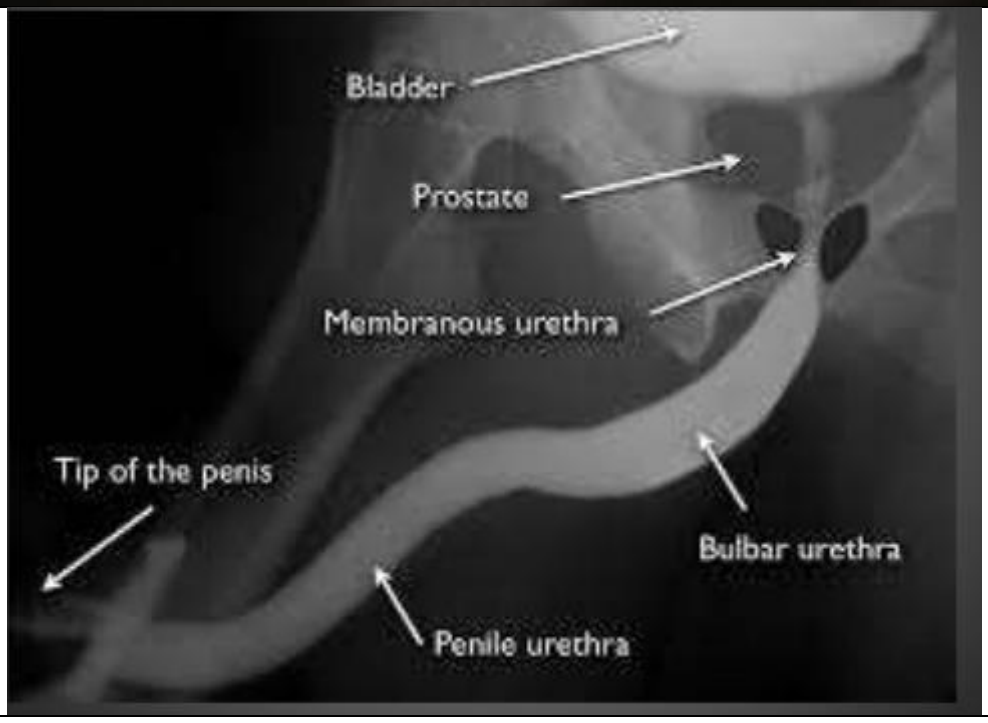


Urinary System

Urethra

Urethral Anatomy





❖ Male Urethral Anatomy

- **Posterior urethra:**
  - **Prostatic urethra**
  - **Membranous urethra**
- **Anterior urethra:**
  - **Bulbous urethra**
  - **Penile urethra**

1) Prostatic urethra (Posterior urethra)

- The prostatic urethra courses within the prostate and is lined with transitional epithelium.
- The verumontanum is a prominent ridge of smooth muscle in the posterior portion of the prostatic urethra, and is the site of the paired ejaculatory duct orifices.

2) Membranous urethra (Posterior urethra)

- Shortest, least mobile urethral segment.
- contained within the urogenital diaphragm
- contains the external urethral sphincter and the paired Cowper's glands.

3) Bulbous urethra (Anterior urethra)

- The bulbar urethra is the site of drainage of Cowper's glands.

4) Penile urethra (Anterior urethra)

- The penile urethra is the longest urethral segment.
- It is lined with squamous epithelium.
- The distal portion of the penile urethra is dilated at the glans penis. This dilation is called the fossa navicularis.
- The glands of Littré are small mucous glands of the penile urethra.

❖ Female urethra Anatomy

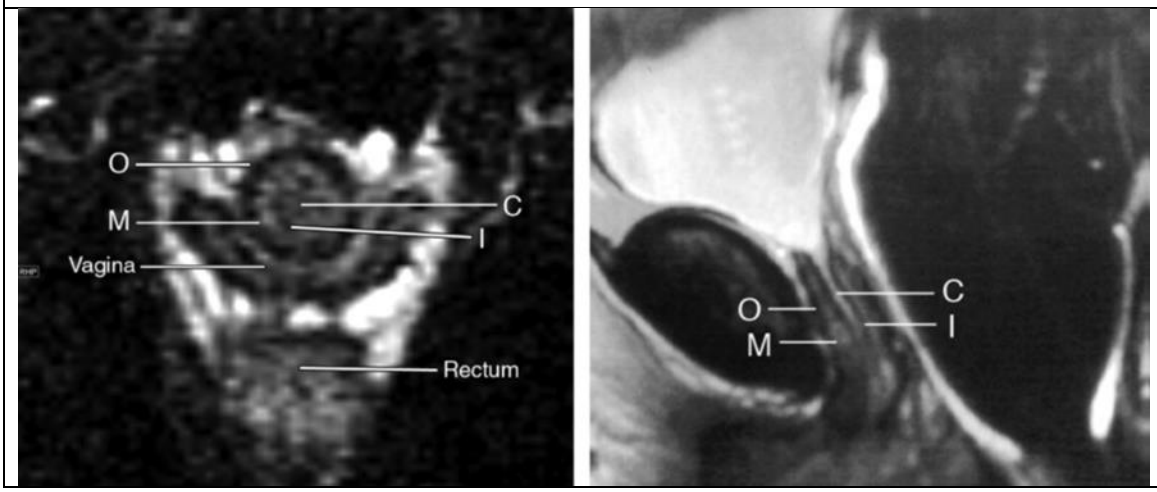
- The female urethra is much shorter than the male urethra.
- The female urethra is not divided into discrete segments.
- The paraurethral glands of Skene are homologous to the male prostate and secrete mucus into the urethra.
- The proximal third of the urethra is lined by transitional epithelium.
- The distal portion of the urethra is lined with a squamous epithelium.

❖ MR Zonal Anatomy

- Axial and sagittal T2 and gadolinium-enhanced T1 MR images has been described as target like due to the alternating signal intensity characteristics of the different zones.

4 rings are as follows:

1) Outermost layer of longitudinal smooth circular striated muscle cells (hypointense),
2) Middle submucosal layer of vascularized connective tissue and smooth muscle cells (hyperintense),
3) Inner mucosal layer of epithelial cells (hypointense),
4) Innermost layer of hyperintense urine or secretions that may or may not be seen



❖ Imaging Modalities

- Voiding cystourethrography
- MRI:
    - Pelvic phased array coil
    - Endocavitary/endovaginal/endorectal coil
- CT Voiding Urethrography and Virtual Urethroscopy
- US:
    - Transvaginal US, 5–9-MHz curved-array transducer is inserted approximately 1–2 cm into the vagina.
    - Transperineal US, 5–10-MHz linear-array transducer is placed on the perineum between the labia
    - Transurethral US, 12.5-MHz endoluminal transducer is placed directly into the urethra

Urethral Congenital Anomalies

1- Posterior urethral valves

- 1st common congenital obstructive lesion of the urethra,

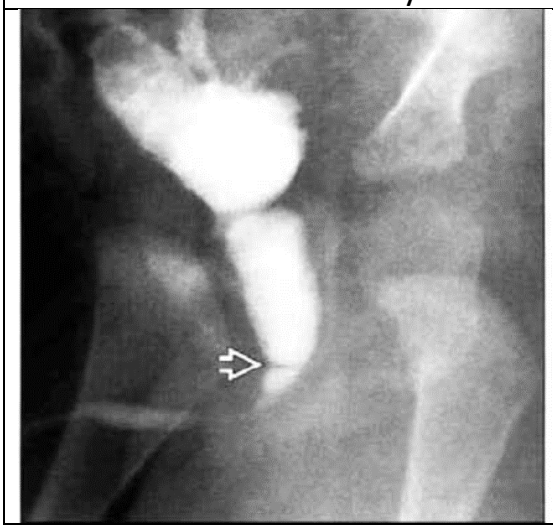
- result from the formation of a thick, valve like membrane from tissue of wolffian duct origin
- Location: from the verumontanum to the most distal portion of the prostatic urethra.

3 types of valves:

Type I: Most common, anterior fusion of plicae colliculi
Type II: Rarest, longitudinal folds from verumontanum to bladder neck
Type III: Rare, disc or windsock-type tissue distal to verumontanum

VCUG:

- Dilatation and elongation of the posterior urethra
- A linear radiolucent band corresponding to the valve
- Abrupt transition from dilated posterior urethra to small bulbous urethra at the level of the valve.
- Actual valve tissue may not be visible



Prenatal US

- Abnormalities are most evident when the valves are severely obstructing
- Oligohydramnios
- Bladder distention
- Fetal ascites
- Bilateral hydroureteronephrosis with parenchymal thinning

Associated findings

- Bladder wall trabeculation, hypertrophy, and diverticula
- Vesicoureteral reflux ± Hydronephrosis
- Urinary ascites
- Urinoma/perinephric urine collection
- Reflux into utricle or other ducts

2- Anterior Urethral Valve

- Rare congenital anomaly that cause lower urinary tract obstruction in children.
- They can occur as an isolated entity or in association with a proximal diverticulum.
- The clinical manifestation of anterior urethral valves is highly variable and depends on patient age and degree of obstruction.
- It may range from severe obstruction with bilateral severe hydroureteronephrosis, end stage renal disease, and even bladder rupture

Location:

- May be found anywhere in the anterior urethra.
- 40% in the bulbar urethra
- 30% at the penoscrotal junction
- 30% in the pendulous urethra

VCUG

- is the diagnostic modality of choice for anterior urethral valve.
- The urethra appears dilated proximal to valve and narrowed distal to it
- A valve may appear as:
    - a linear filling defect along the ventral wall.
    - it may be indicated by a dilated urethra ending in a smooth bulge
    - or an abrupt change in the caliber of the dilated urethra.

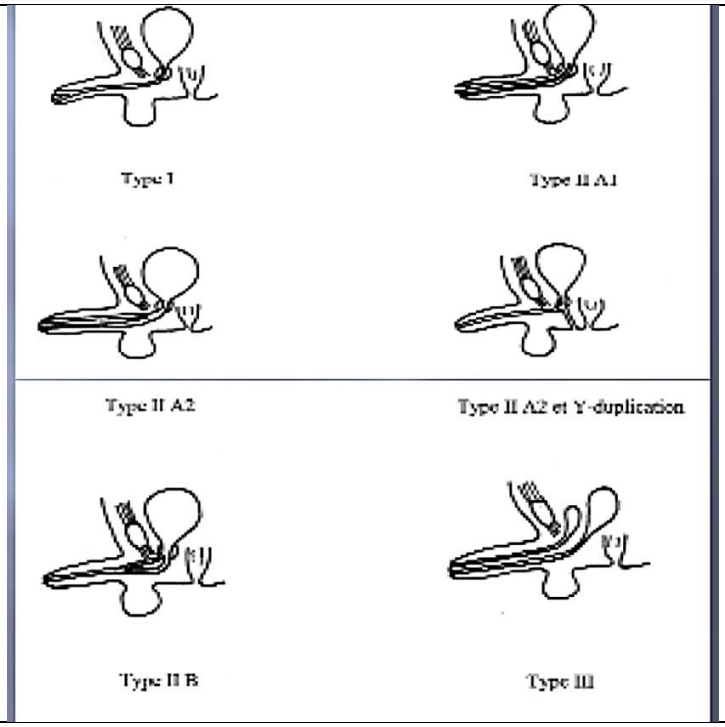
3- Urethral Duplication

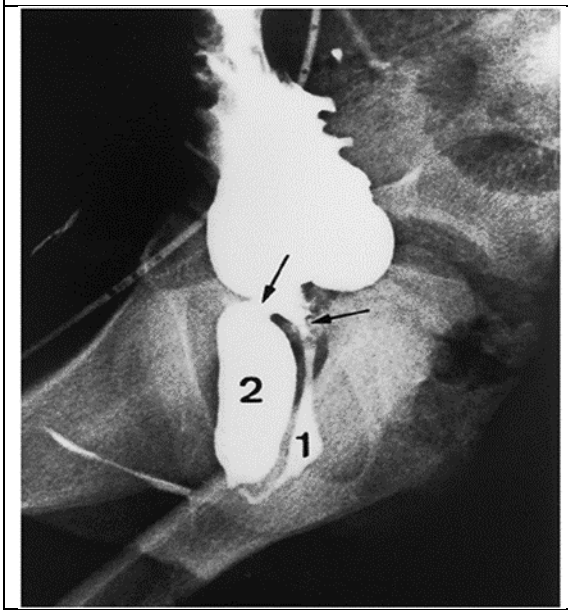
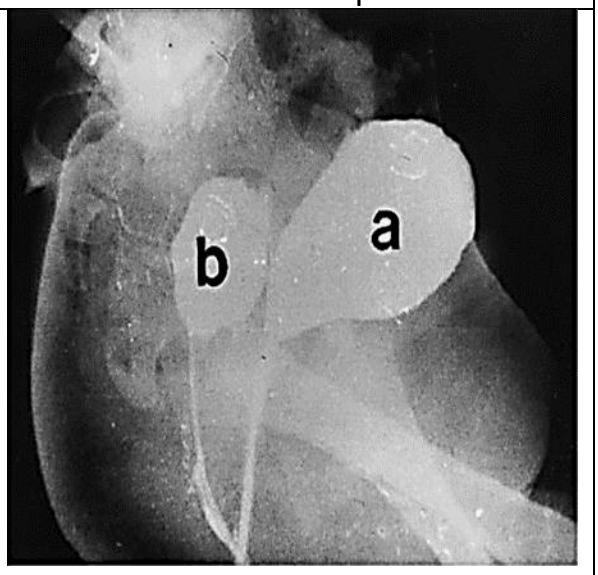
- (accessory urethra) is a rare anomaly.
- it occurs in the coronal plane; collateral (side-by-side) duplication in the absence of bladder duplication also exists

Classification by Effmann et al :

Classification Scheme for Urethral Duplication

Type	Characteristics
I	Incomplete urethral duplication
IIa	Complete urethral duplication with two meatus
IIb	Complete duplication joining at one meatus
III	Urethral duplication as a component of caudal duplication



Incomplete urethral duplication	Complete duplication of the bladder and urethra in coronal plane
	

4- Urethral Diverticulum

- 2nd most common cause of congenital urethral obstruction in boys
- A lip of tissue may be seen around the diverticulum. As the diverticulum distends, the lip of tissue is pressed against the urethral wall and results in a valvelike obstruction

Clinical Diagnosis:

- Diagnosed in infancy with dribbling-type micturation or infection.
- The dribbling may be due to emptying of the diverticulum or to overflow incontinence.
- If the obstruction is distal, ballooning of the urethra may occur with voiding

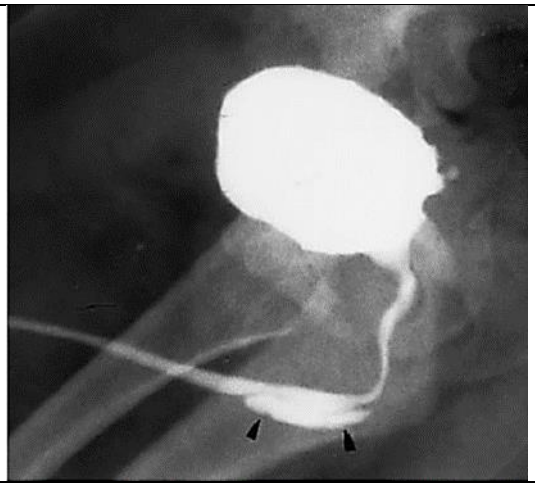
VCUG:

- the typical saccular diverticulum of the anterior urethra fills with contrast material and appears as an oval structure on the ventral aspect of the anterior urethra

5- Syringocele

- Cystic dilatation of the Cowper gland ducts.

- The Cowper glands are paired paraurethral glands located in the urogenital diaphragm near the bulbous urethra.

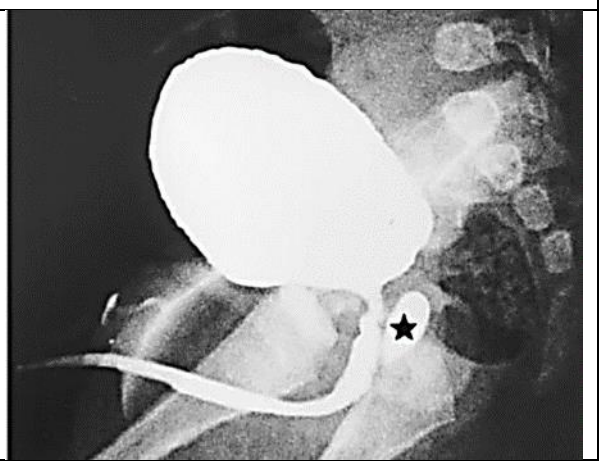


6- Prostatic Utricle

- is a short, blind-ending pouch located on the verumontanum (ie, the floor of the prostatic urethra)
- represents a mesodermal remnant of the Muller tubercle formed by the fused, paired distal mullerian ducts
- In males, the mullerian ducts regress under the influence of mullerian inhibiting factor produced by the fetal testis, leaving the prostatic utricle as a vestige.

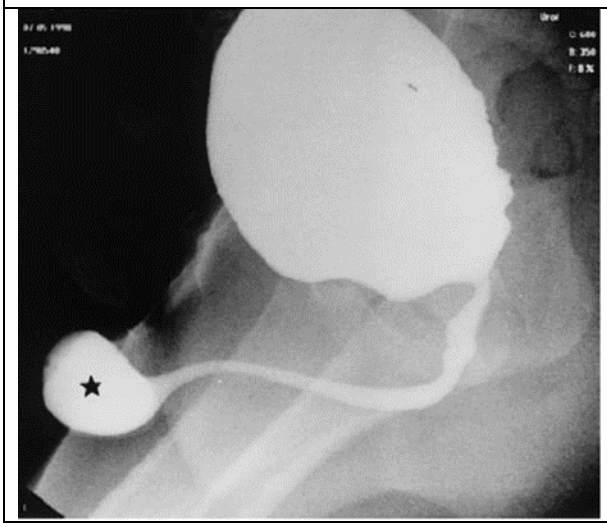
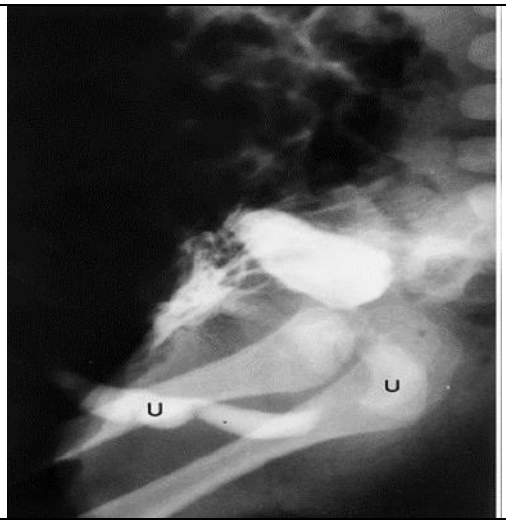
<u>VCUG:</u>

- An opacified prostatic utricle is usually well demonstrated at lateral VCUG, appearing as a posterior urethral diverticulum.
- Occasionally, urethral diverticula may be gigantic



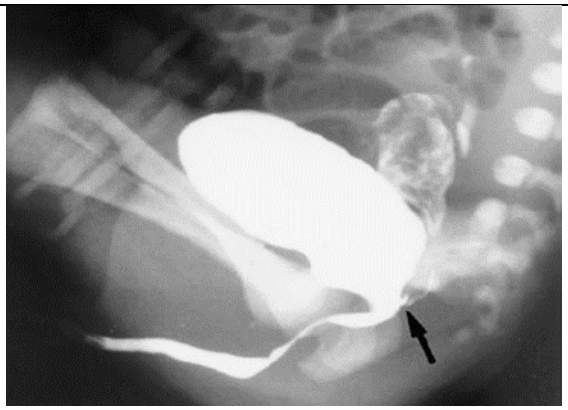
7- Megalourethra

- Megalourethra is a rare congenital disorder.

Scaphoid Type (Mild Form):	Fusiform Type (Severe Form)
• Due to poor development of the corpus spongiosum, • The urethra dilates in a scaphoid (boat-shaped) fashion during voiding because the dorsal aspect is supported by the intact corpora cavernosa	• The corpora cavernosa are also affected • Characterized by a long, dilated, floppy urethra that results from a congenital deficiency of the corpora cavernosa
	

8- Urethral Fistula

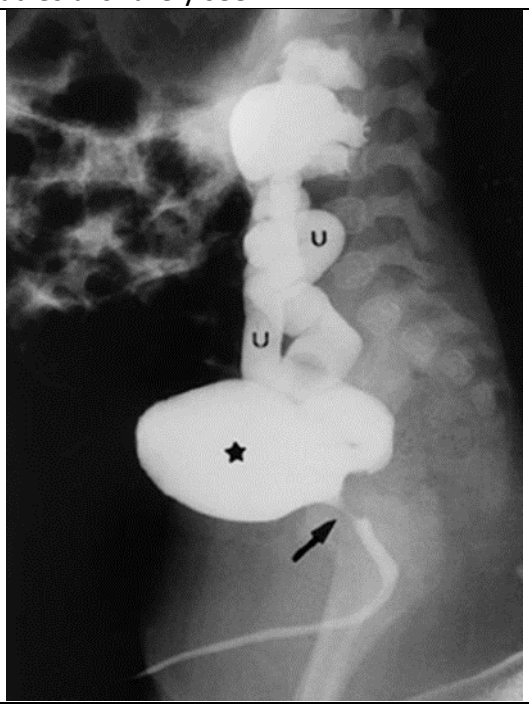
- Imperforate anus is the most common abnormality of the anorectal segment and occurs when the terminal bowel fails to descend normally, resulting in a lack of communication with the anus a result, the bowel may open via a fistula at an abnormal location.
- Boys with high imperforate anus frequently have a connection from the rectum to the lower urinary tract, usually at the level of the prostatic urethra



9- Congenital Urethral Stricture

- A localized narrowing at the junction of the posterior and anterior urethra.
- Less frequently, it can be located below the bladder neck.
- Other types of congenital stenosis are rare and may occur at any level of the penile and bulbous urethra
- Segmental urethral stenosis or complete atresia is rarely seen.

- Findings above the stenotic segment are similar to those of posterior urethral valves and include wall bladder thickening, hydronephrosis,
- and renal dysplasia.
- VCUG demonstrates the stenotic segment and the associated alterations



10-Epispadias

- is a rare congenital anomaly that is almost always associated with bladder exstrophy.
- The roof of the urethra is absent, and the urethra opens anywhere between the base and the glans of the penis.

11-Hypospadias

- Hypospadias is a congenital defect of the anterior urethra, which opens anywhere along the ventral aspect of the penile shaft.
- The presence of hypospadias is thought by some to be a form of intersex.
- Although VCUG or RUG can demonstrate the urethra per se, the anatomy of the urethra and adjacent structures can be better evaluated with MR imaging

Urethral Diverticulum

- are protrusions of the urethra into the periurethral fascia.
- its epithelial lining is identical to the urethral mucosa,
- communication with the urethral lumen is maintained

- F>>>M
- Age: can occur at any age, mostly (3rd to 5th decades.)
- Site: Most commonly, it occurs in the midurethra and on the posterolateral wall rather than on the anterior wall.

Aetiology: Acquired:

- The vast majority of urethral diverticula are from acquired causes,
- the most widely accepted theory involving rupture of a chronically obstructed and infected periurethral Skene gland into the urethral lumen.
- The outpouching epithelializes over time and becomes a true diverticulum lined with urothelium
- Escherichia coli and, less often, gonococci and Chlamydia

Aetiology: Congenital

- A pediatric urethral diverticulum is rare and is likely congenital.
- Proposed theories of congenital etiologies include an origin from cloacogenic rests, müllerian cell rests, Gartner duct remnants, or incorrect union of primordial urogenital sinus folds

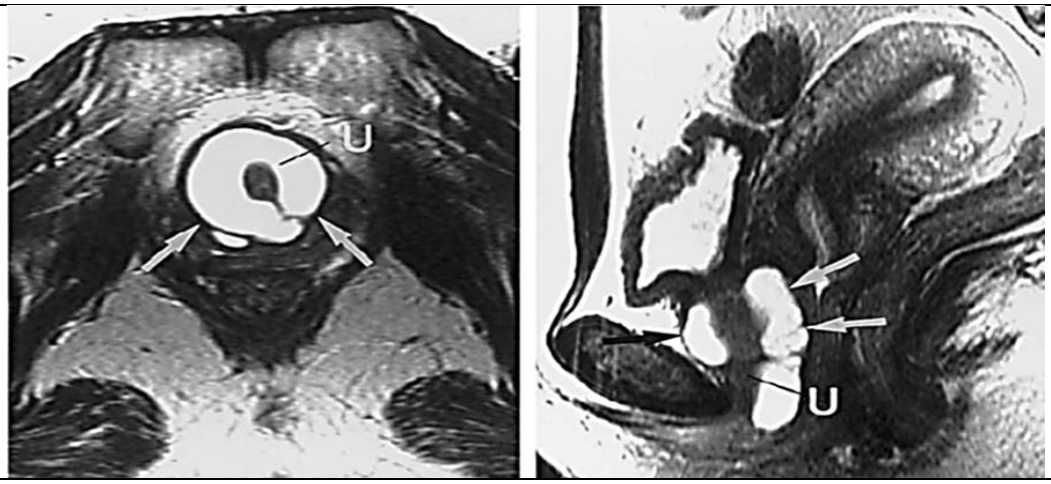
Classic clinical manifestation “triad of Ds”:

- ***Dysuria, Dyspareunia, and Postvoid Dribbling***.

MRI appearance

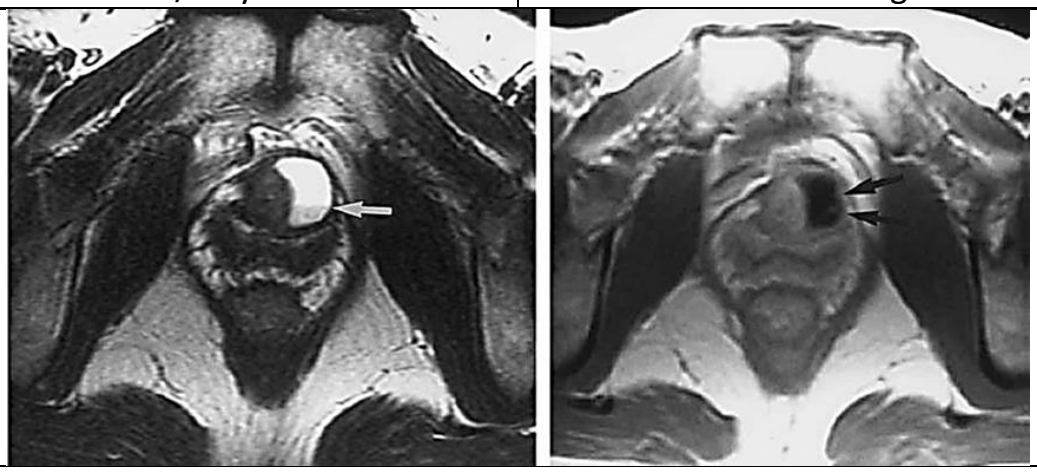
- Location: it arise from the posterolateral wall of the midurethra at the level of the pubic symphysis.
- Single or multiple
- Unilocular or multiseptated;
- A narrow or wide neck
- Various degrees of extension around the circumference of the urethra.

- A simple urethral diverticulum is round or oval and usually located lateral or posterior to the urethra,
- A U-shaped diverticulum extends partially around the urethra,
- A circumferential diverticulum extends completely around the urethra, often having a “saddlebag” appearance



❖ Infected uretheral diverticulum:

Axial T2: Fluid / fluyid lvel	Axial T1: thick enhancing wall



Urethral Stricture

Causes:

- **Inflammatory:**
  - **Infectious urethritis**
  - **Balanitis xerotica obliterans**
- **Traumatic**
  - **Straddle injury**
  - **Iatrogenic instrumentation**
- **Congenital**

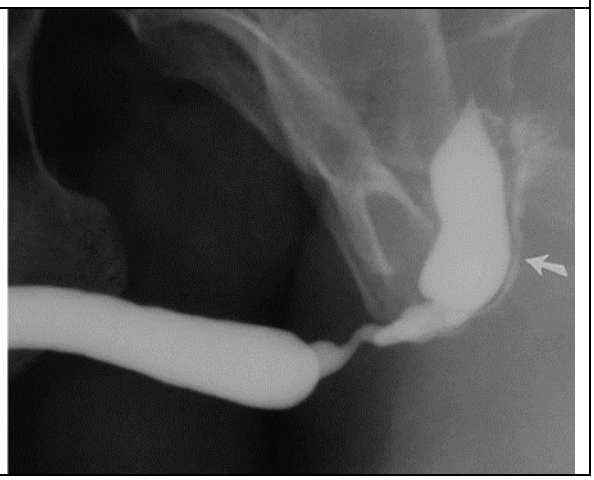
Inflammatory Diseases

A- Gonococcal Urethritis

- Gonococcal urethritis is associated with the gram-negative diplococcus, Neisseria gonorrhoeae.
- Although gonorrheal infection has become less prevalent since the early 1980s, it remains the leading reportable sexually transmitted disease in adults in the United States.
- Patients with gonococcal urethritis usually present with purulent urethral discharge

- Urethral stricture is an irregular urethral narrowing several centimeters long.

- 15% of men with gonococcal urethritis go on to develop stricture, with an interval of 2–30 years between infection and the onset of obstructive symptoms.



<u>Imaging findings:</u>

- Hard fibrous scars are present at the distal portion of the bulbous urethra in 70% of patients.
- The proximal cone-shaped bulbar urethra appears to be narrowed, elongated, asymmetric, irregular, or absent, the stricture is seen to extend into the membranous urethra in more than 90% of cases
- This radiologic finding is of prime importance to the urologist because surgical treatment may involve cutting the scar tissue and, consequently, the distal sphincter, which could result in iatrogenic incontinence.

B- Nongonococcal Urethritis

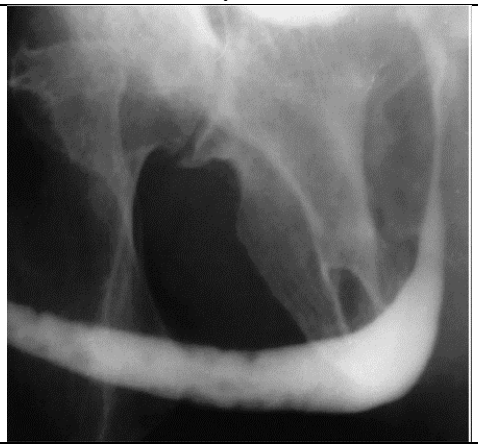
i) Chlamydia trachomatis

- Chlamydia trachomatis is the most common pathogen of nongonococcal urethritis, accounting for 30%–50% of cases.

ii) Condyloma Acuminata

- Caused by viral infection.
- Produce soft, sessile, squamous papillomas on the penile glans and shaft and the prepuce.
- Condyloma acuminata are termed venereal warts.
- Urethral involvement occurs in 0.5%–5% of male patients.

The typical urethrographic findings are multiple papillary filling defects in the anterior urethra

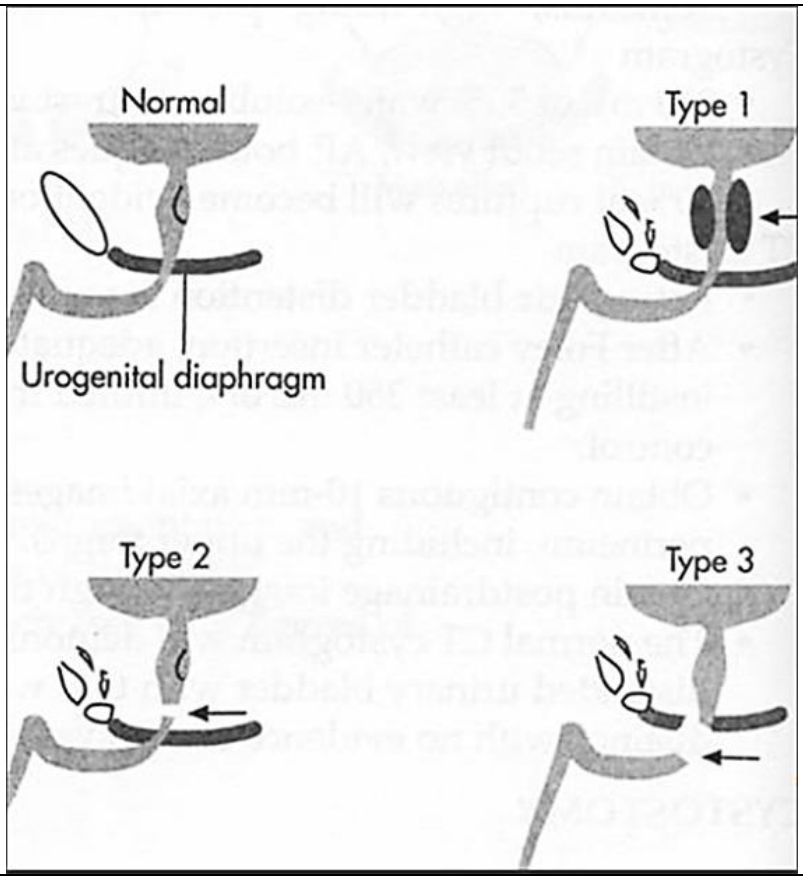


iii) Tuberculosis of the urethra

- is very rare.
- Usually, genital tuberculosis is a descending infection and renal tuberculosis is evident.
- The prostate is involved in 70% of patients with genital tuberculosis.
- Prostatic abscess may rupture into any surrounding structure, which results in prostatorectal and prostatoperineal urethral fistulas.
- In the acute phase, there is urethral discharge with associated involvement of the epididymis, prostate, and other parts of the urinary system.

Urethral Injury

- **Type I:** Posterior urethra stretched but intact
- **Type II:** Urethra disrupted at the membrano-prostatic junction above the urogenital diaphragm => Contrast extravasation in the retropubic space
- **Type III:** Membranous urethra disrupted with extension to proximal bulbous urethra and/or disruption of the urogenital diaphragm (most common) => Contrast extravasation in the perineum.
- **Type IV:** Bladder neck injury with extension into the urethra
- **Type IVA:** Injury of the base of the bladder with periurethral extravasation simulating a true type IV urethral injury
- **Type V:-** Partial or complete pure anterior urethral injury



Iatrogenic Trauma

- Iatrogenic trauma to the urethra may result from pressure necrosis at fixed points in the urethra from indwelling catheters.
- Location: bulbomembranous region and, less commonly, at the penoscrotal junction.
- Iatrogenic stricture of the prostatic posterior urethra ("bladder neck contracture") usually occurs after transurethral resection of the prostate or open radical prostatectomy

Post-irradiation Injuries

- Urethral complications following radiation therapy (external irradiation and radiation seed implant brachytherapy) include:
    - Uethritis
    - Urethral stricture
    - Urethral fistula.
- Prostatic urethra-rectal fistula has been reported to occur in 1% of patients after prostate brachytherapy for prostate cancer

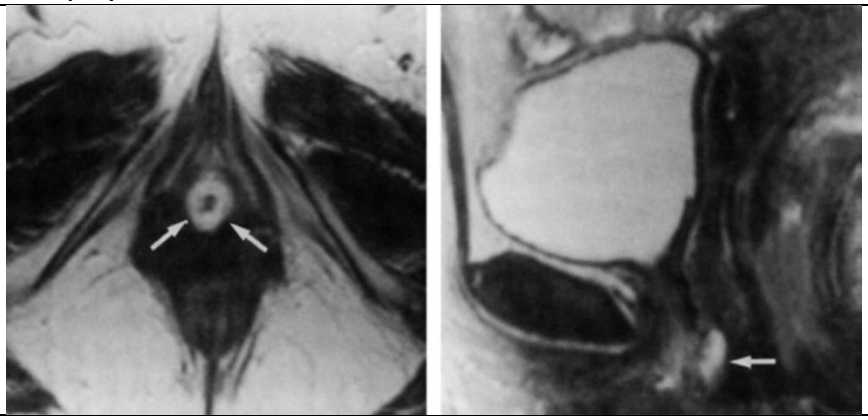
Urethral Lesions

1) Urethral Caruncle

- Small benign lesions of the posterior margin of the external urethral meatus that are caused by distal urethral prolapse in hypoestrogenic postmenopausal women
- Histologic examination of a caruncle reveals hyperplastic squamous epithelium with submucosal vascularity, fibrosis, and inflammation
- Conservative treatment in symptomatic patients includes sitz baths and the application of topical estrogen

Imaging findings:

- T2- hyperintense tissue surrounding the external urethral meatus, a finding that correlates with the presence of a soft exophytic lesion at the meatus at physical examination



2) Urethral Leiomyoma

- extremely rare,
- Benign smooth muscle tumors that may grow during pregnancy and result in dysuria.

Imaging findings:

- Non degenerating leiomyoma:-
    - T1 Intermediate
    - T2 Low
    - Contrast enhancement
- Degenerating leiomyomas:-
    - have variable appearances

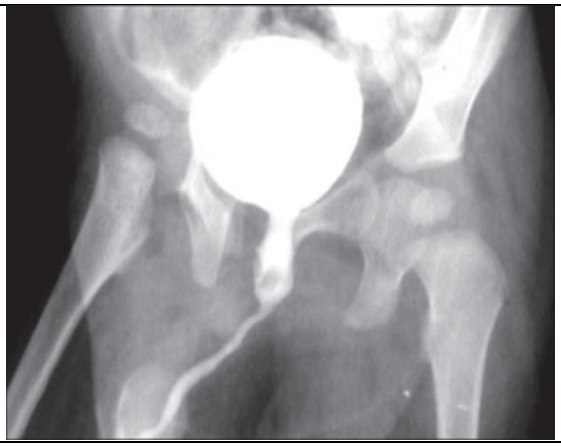
3) Fibroepithelial polyp

- Fibroepithelial polyp of the male urethra is of embryonic origin,
- originating in the prostate and projecting into the urethra
- This condition manifests at birth with hematuria or obstructive voiding symptoms.
- Fibroepithelial polyps of the urethra are usually diagnosed during the first decade of life.
- They present with obstruction, voiding dysfunction and hematuria.

Location:

- The polyp is connected to the verumontanum via a stalk, which allows the polyp to rest in the prostatic urethra or even extend through the bladder neck into the bladder.

- During the voiding phase of cystourethrography, the polyp typically appears as a smooth filling defect extending into the midpoint of the bulbar urethra.



4) Primary Urethral Carcinoma

- Rare neoplasm that accounts for less than 0.02% of all malignancies in women.
- Postmenopausal Caucasian women are most commonly affected.

Significant risk factors:

- Chronic urinary tract infections and irritation
- Urethral diverticula
- Human papilloma virus infection
- Proliferative lesions of the urethra such as caruncles, adenomas, polyps, and leukoplakia

Squamous Cell Carcinoma:

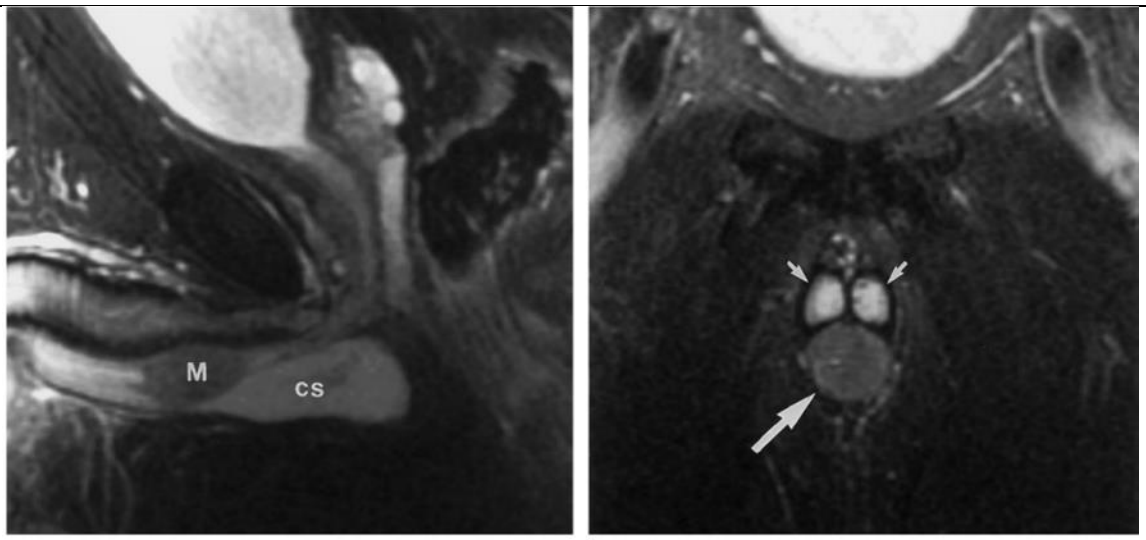
- Most common subtype (70% of cases)
- Location: anterior urethra and the external urethral meatus.
- Drain primarily to the superficial and deep inguinal lymph nodes.
- Better prognosis
- Treated with local surgical excision.

Transitional cell carcinoma:

- Transitional cell carcinoma (20% of cases) and adenocarcinoma (10%)
- Location: Posterior urethra
- Drain primarily to the external iliac, hypogastric, obturator, and paraaortic lymph nodes
- Manifest as high-grade locally advanced tumors, often requiring a combination of surgery, radiation therapy, and chemotherapy

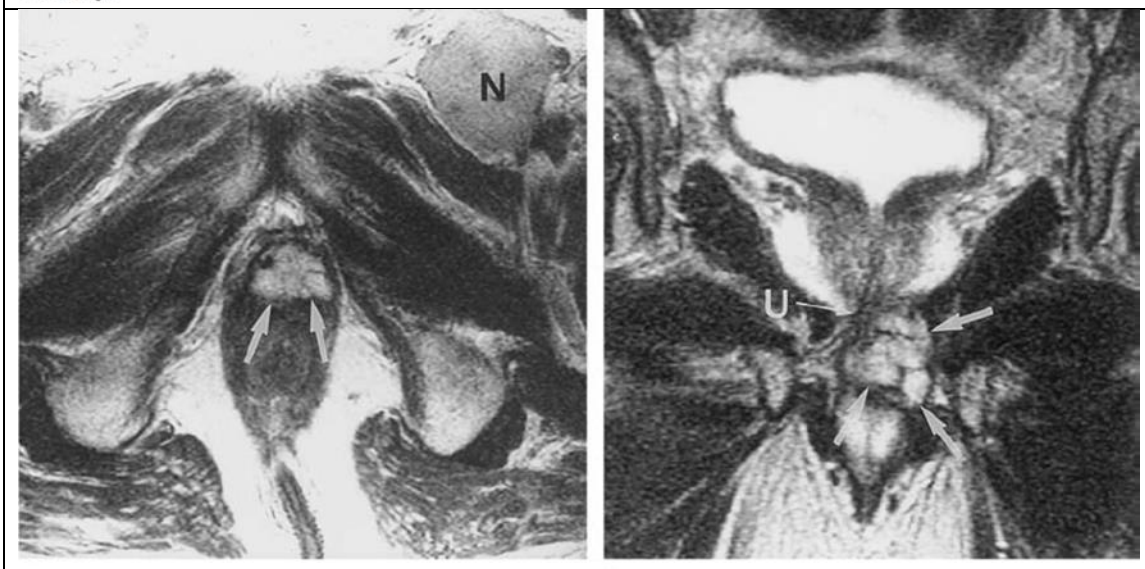
Staging:

- Stage I urethral tumor is confined to the subepithelial connective tissue.
- Stage II tumor invades the corpus spongiosum, prostate, or periurethral muscle.
- Stage III tumor invades the corpus cavernosum and bladder neck or beyond the prostatic capsule.
- Stage IV tumor invades other adjacent organs.



a. b.

Figure 26. Squamous cell carcinoma of the male urethra. **(a)** Sagittal fast spin-echo T2-weighted MR image demonstrates a focal mass *(M)* with low signal intensity in the corpus spongiosum *(cs)* at the penoscrotal junction. **(b)** Coronal MR image shows that the mass (large arrow) occupies the corpus spongiosum but has not invaded the corpora cavernosa (small arrows), which are intact. The patient underwent perineal partial urethrectomy.



a. b.

Figure 16. Adenocarcinoma arising from the Cowper gland in a 59-year-old man. **(a)** Axial T2-weighted image shows a multilobulated soft-tissue mass of intermediate signal intensity (arrows) in the left side of the membranous urethra within the urogenital diaphragm. An enlarged left inguinal lymph node (*N*) is also seen. **(b)** Coronal T2-weighted image shows that the distal prostatic urethra (*U*) is displaced by the tumor (arrows).

5) Secondary Urethral Tumors

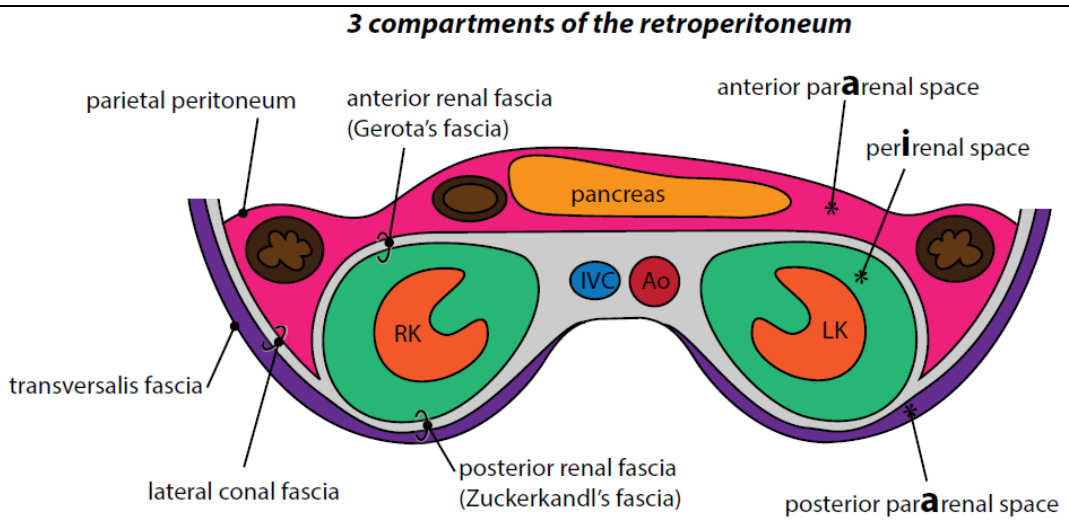
- Rare tumors that extend contiguously from the urinary bladder, cervix, vagina, uterus, and anus.
- 2%–13% of women with primary transitional cell carcinoma of the urinary bladder will have extension to the proximal urethra at diagnosis
- seeding of the anterior urethra may occur during urethral instrumentation
- Hematogenous tumor spread to the urethra is very rare, with melanoma being the most common metastatic lesion

Adrenal Gland

&

Retroperitoneum

Retroperitoneum Anatomy



It is the portion of the abdomen posterior to the peritoneal cavity from the diaphragm to the pelvic inlet.

- Anteriorly: separated from the peritoneum anteriorly by the posterior peritoneal fascia
- Posteriorly: is bounded posteriorly by the transversalis fascia.

❖ Classic Tri-compartment Model => 3 Spaces

Space	Boundaries	Contents
Anterior pararenal	Peritoneum, anterior perirenal fascia, latero-conal fascia	Pancreas, duodenum, ascending colon, descending colon
Perirenal	Anterior and posterior renal fasciae	Kidneys, adrenal glands, proximal renal collecting systems, renal hilar vessels
Posterior pararenal	Posterior renal fascia, transversalis fascia, fascia over the psoas muscle continuous with the transversalis fascia	Fat

Retroperitoneal Lesions

1) Imaging Features:

A- Retroperitoneal Fat Lesions

- Lipoma / Lipomatosis.
- Lipoblastoma
- Teratoma
- Liposarcoma
- Renal => Angiomyolipoma
- Adrenal => Myelolipoma

B- Retroperitoneal Cystic Lesions

Neoplastic Cysts	Non-neoplastic Cysts
• Lymphangioma • Mucinous Cystadenoma • Cystic Mesothelioma • Cystic Teratoma • Cystic Change in Solid Neoplasm • Pseudomyxoma Retroperitonei. • Perianal Mucinous Carcinoma.	• Heamtoma • Urinoma • Lymphocele • Pancreatic pseudocyst • Abscess (Pot's Disease) • Lymphangioleiomatosis (Tubers Sclerosis) • Tail gut cyst • Mullerian Cyst

C- Retroperitoneal Myxoid Lesions

- Neurogenic tumors
- Myxoid liposarcoma
- Myxoid malignant fibrous histiocytoma

D- Retroperitoneal Solid Lesions

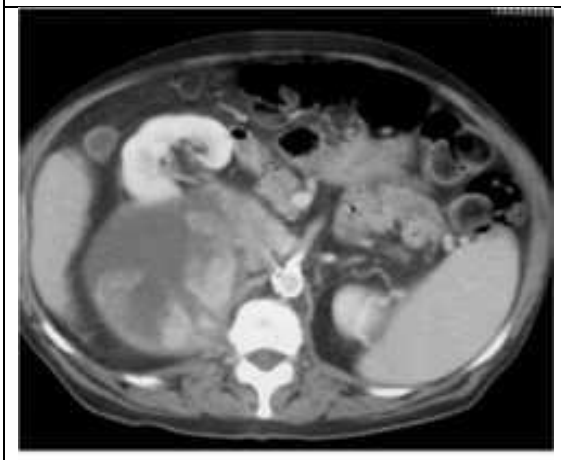
- **Lymphoma – Metastatic Lymphadenopathy**
- **Sarcomas**
  - Liposarcoma
  - Malignant fibrous histiocytoma
  - Leiomyosarcoma
- **Neurogenic tumors**
  - Schwannoma – Neurofibroma - Paraganglioma
  - Neuroblastoma – Ganglioneuroblastoma – Ganglioneuroma
  - Malignant peripheral nerve sheath tumors

E- Retroperitoneal Fibrosis

Approach to Retroperitoneal Masses

2) Determining Tumor location into the retroperitoneal spaces:

- Displacement of normal retroperitoneal structures, such as retroperitoneal organs or vascular structures suggests that a mass is retroperitoneal in location

Anterior displacement of the kidney	Anterior displacement of the descending colon (arrow)
	

3) Excluding organ of origin

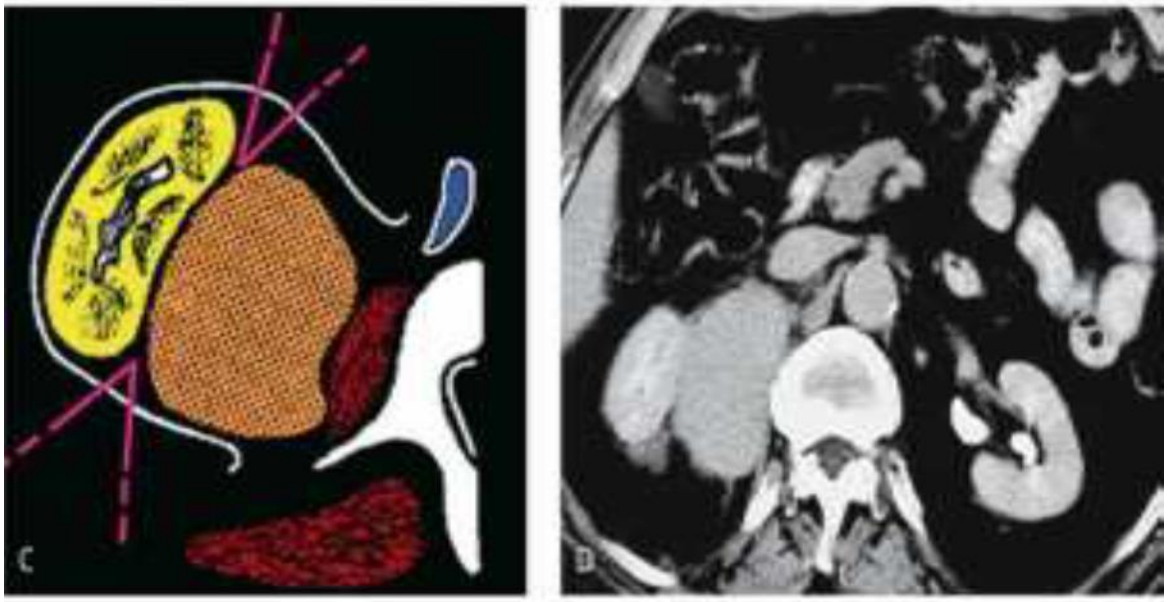
- In order to classify a mass as primary retroperitoneal, the possibility that it arises from a retroperitoneal organ must be excluded.
- Several radiographic signs are instructive:
  - Claw or beak sign.
  - Embedded organ sign.
  - Invisible organ sign (phantom organ sign).
  - Prominent Feeding Artery Sign.

i) Positive beak sign:

- A mass that originates from a particular organ will form acute angles with it and at least partially surround it in the shape of a claw or beak.
- The appearance is supported by parenchymal taken that “envelop” the tumor.
- The lesion originates from the organ (renal mass)

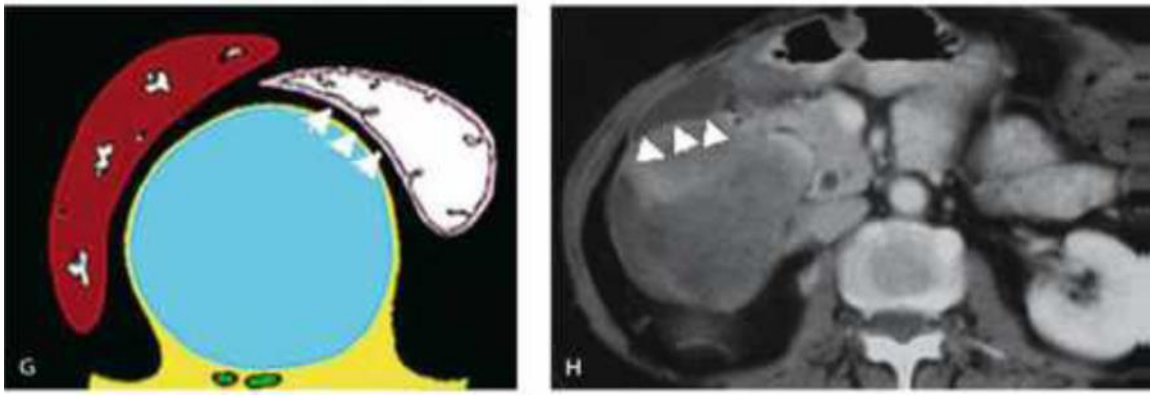
ii) Negative beak sign:

- The tumor does not originate from the organ, which is also compressed.
- An acute angle forms at the contact points between the resident organ and the lesion (retroperitoneal mass)



iii) Embedded Organ Sign:

- A mass that arises from a given organ often appears embedded within in and the interface between the two may be difficult to appreciate.
- Conversely, a mass that abuts but does not originate from a hollow structure compresses it to produce a crescentic deformity

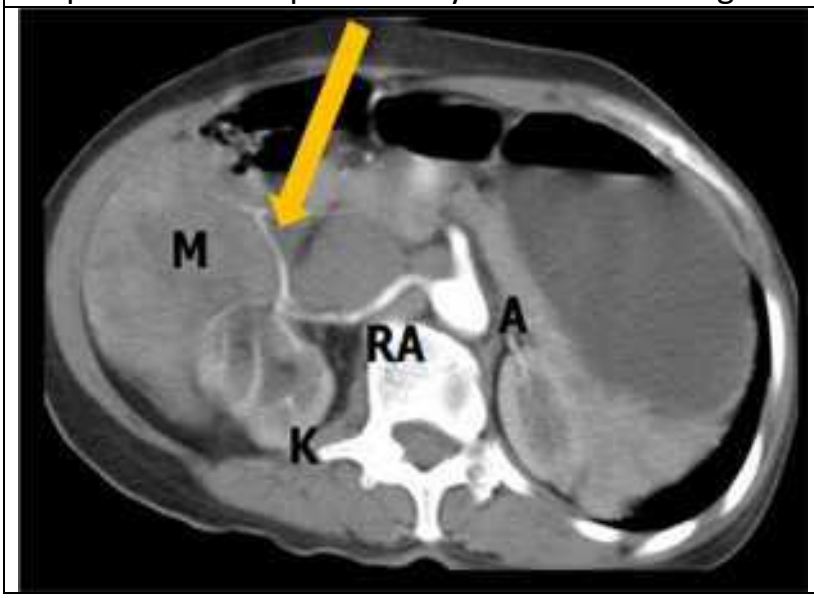


iv) Invisible Organ Sign (Phantom Organ Sign):

- A large mass, particularly when arising from a small organ, may render the organ of origin undetectable
- Conversely, absence of the invisible organ sign suggests primary retroperitoneal pathology

v) Prominent Feeding Artery Sign:

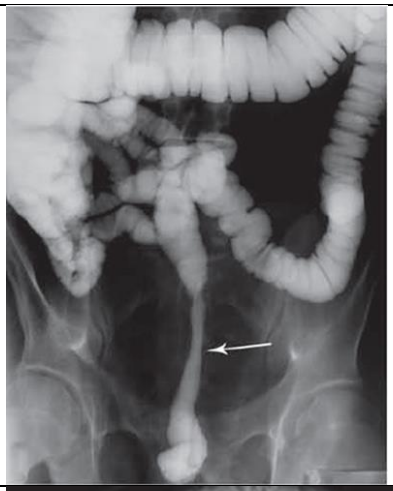
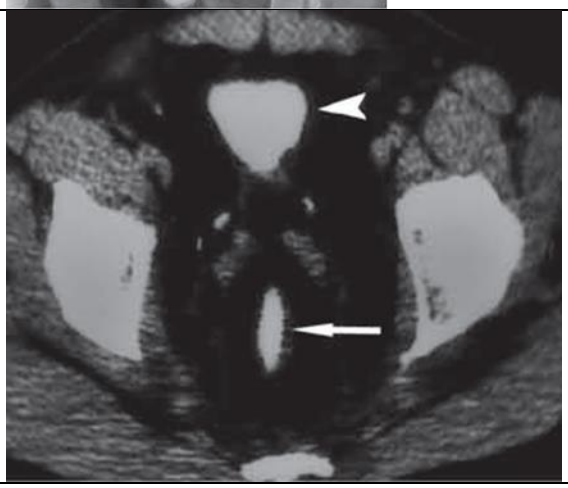
- Hypervascular masses are often supplied by feeding arteries that are prominent enough to be visualized at CT or MR imaging, a finding that provides an important key to understanding the origin of the mass.



I- Retroperitoneal Fat Containing Lesions

1) Lipomatosis

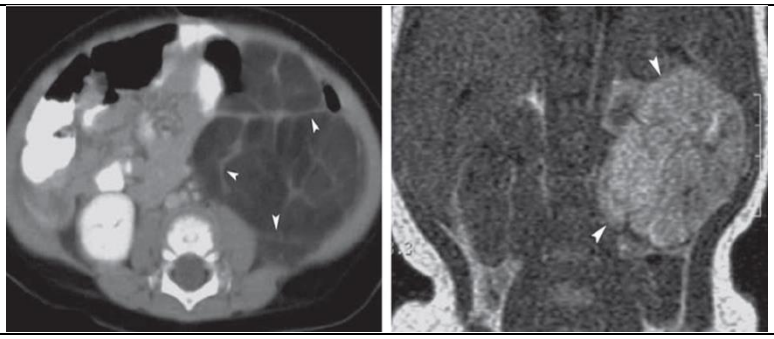
- Pelvic lipomatosis is the overgrowth of histologically benign, mature, white fat in the extraabdominal compartments of the pelvis along the perirectal and perivesicular spaces

Cystogram	Ba Enema
Urinary bladder displaced superiorly and anteriorly, as well as being compressed. The compression is usually symmetric, creating what has been described as either a pear shape or an inverted teardrop	The rectum appears both elongated and straightened, with superior displacement of the distal sigmoid colon On lateral views, the presacral space is thickened.
	
CT/MRI: • The pelvis appears crowded because of overabundant amounts of symmetrically distributed fat • Occasionally, the homogeneously deposited fat is disrupted by a few strands of fibrous tissue, but no soft-tissue mass is present. • The fat does not enhance and the soft-tissue planes of the pelvis are preserved.	

2) Lipoblastoma

- Lipoblastoma and lipoblastomatosis are rare soft tissue neoplasms that are derived from fetal adipose tissue and that occur in infants and young children.
- The diagnosis has been made in newborns and in patients as old as 16 years of age.

- Lipoblastomas tend to be encapsulated predominanatly fat containing lesion with internal septa
- Lipoblastomatosis is unencapsulated and shows signs of muscle infiltration.



3) Hibernoma

- Hibernoma is a rare, benign, soft-tissue tumor composed of brown fat.

- Brown fat occurs in human newborns, but it substantially regresses by the age of 8 weeks.
- Residual brown fat may remain, however, and hibernomas may arise in these locations, which include:
    - Thigh, Buttock, Scapular region, Trunk, Neck, Mediastinum, Chest wall, Perirenal areas, Breast, Scalp, Periureteric regions

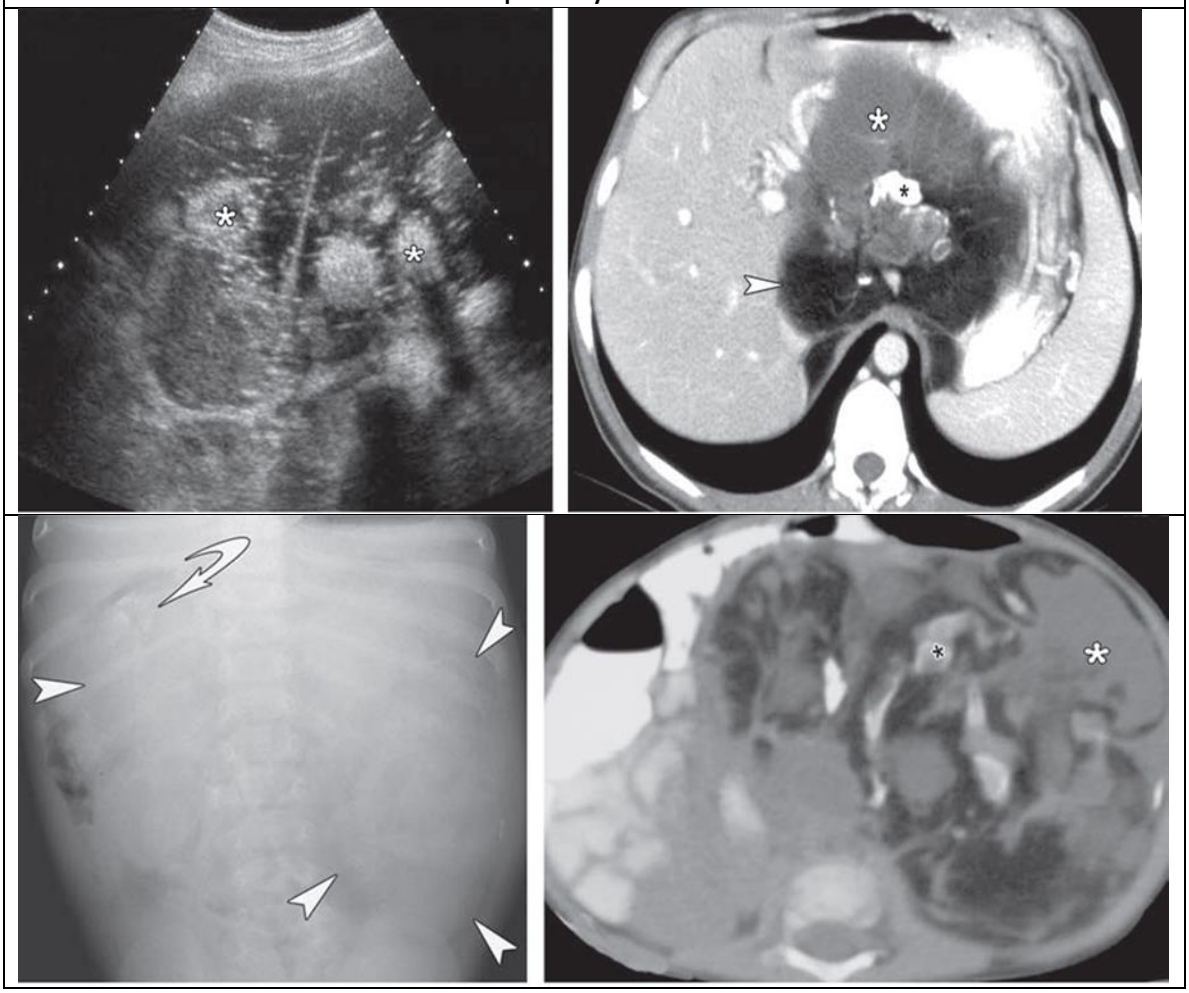
- A well-defined low-attenuation lesion with intratumoral septa is typically seen.

4) Teratoma

- Retroperitoneal teratomas represent approximately 1%–11% of all primary retroperitoneal Tumors.
- Teratomas usually occur in the ovaries, testes, anterior mediastinum, presacral and coccygeal areas, and retroperitoneum

Imaging findings:

- The morphologic features of teratoma extend from predominantly cystic to completely solid lesions.
- Fat and calcifications are frequently identified within these lesions.



5) Liposarcoma

- Primary retroperitoneal sarcomas are both rare and diverse.
- Liposarcoma is the most common retroperitoneal sarcoma
- 35% of all malignant retroperitoneal soft-tissue tumors in adult patients.
- Age: 50–70-year age

Liposarcoma can be subclassified into 5 groups:

a) **Well-differentiated liposarcoma**
b) **Myxoid liposarcoma**
c) **Dedifferentiated liposarcoma**
d) **Round cell liposarcoma**
e) **Pleomorphic liposarcoma**

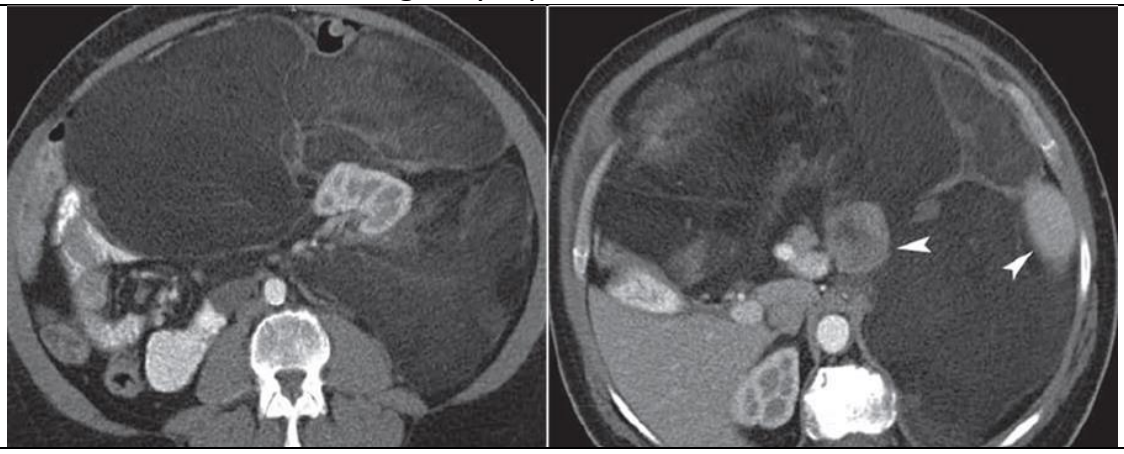
a) Well-differentiated Liposarcoma

- 1st common subtype of liposarcoma
- Low-grade tumors
- High rate of local recurrence
- Predominantly fat containing lesion +
- Enhancing solid areas / nodules / septae
- No clear demarcation between solid and fat

DD: large exophytic renal angiomyolipoma.

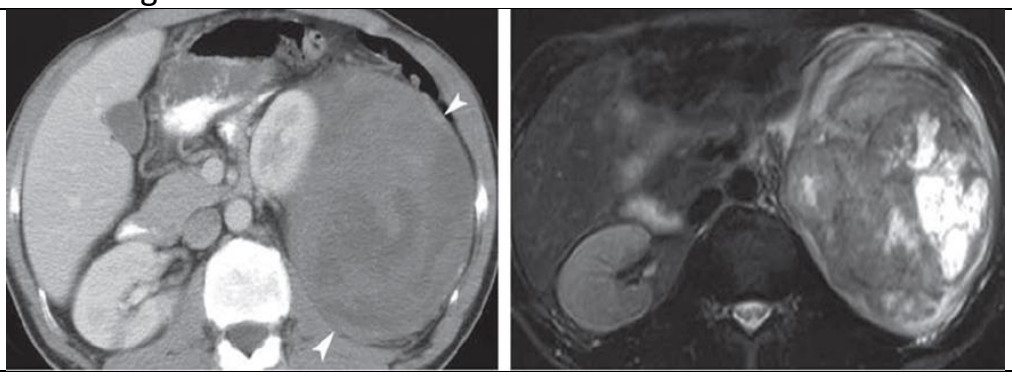
Features that suggest an angiomyolipoma are:

- Renal parenchymal defect from which the mass arises
- Enlarged intratumoral arteries.
- Presence of other angiomyolipomas



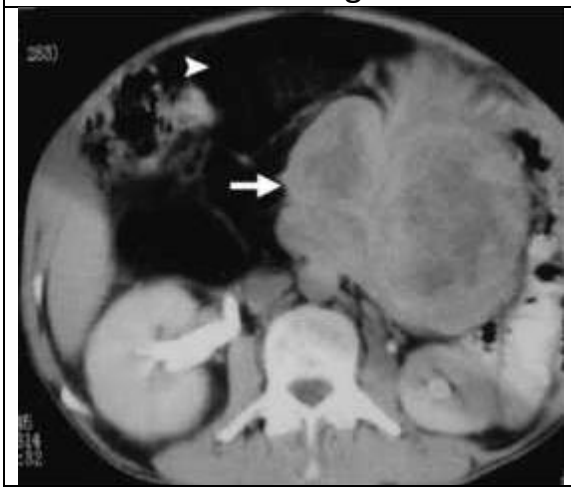
b) Myxoid Liposarcoma:

- 2nd most common subtype of liposarcoma
- Intermediate prognosis
- Myxoid matrix + small amounts of mature fat
- CT: Low attenuation
- T2: High signal "pseudocystic"
- +C: Heterogonous enhancement.



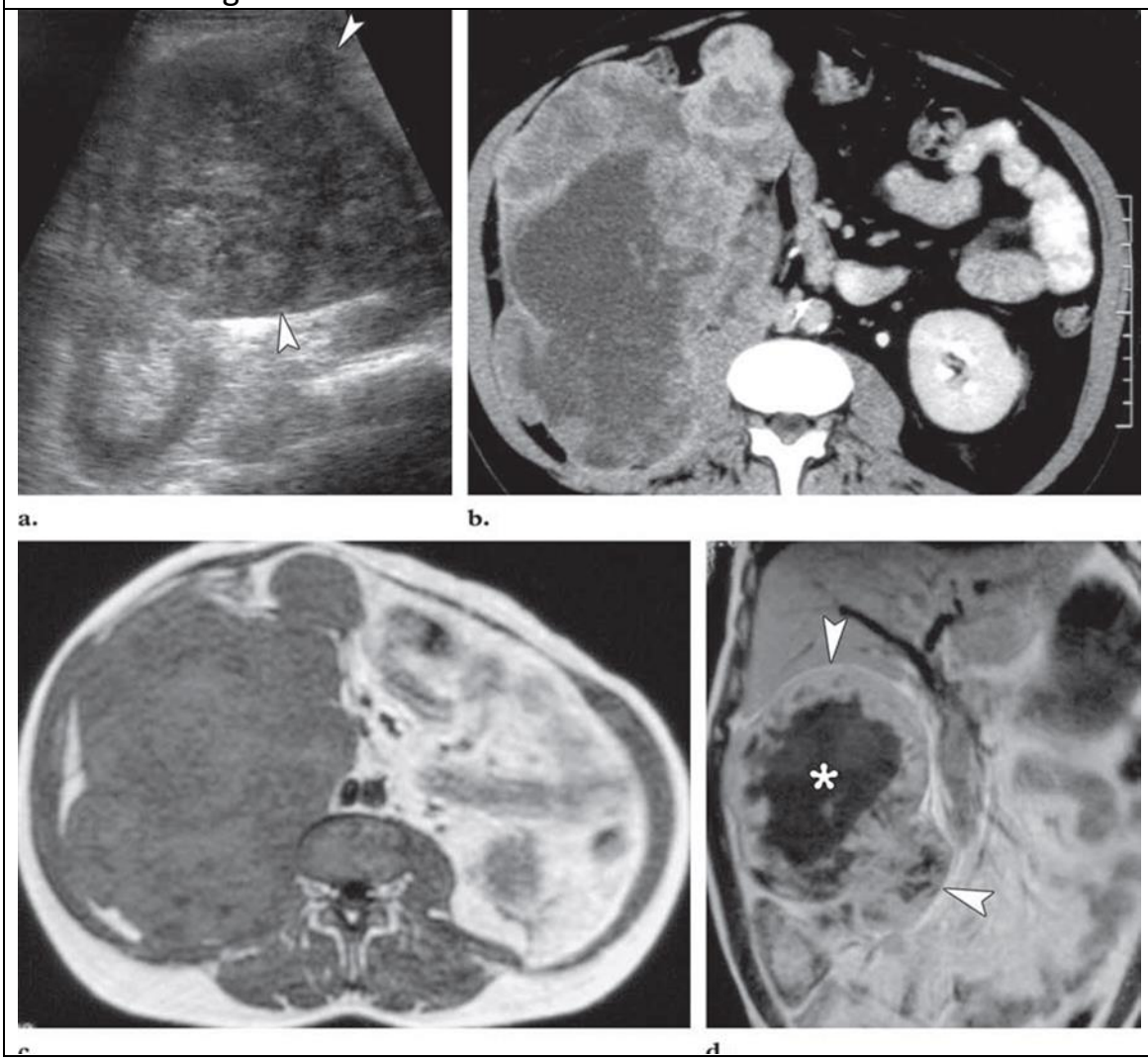
c) Dedifferentiated liposarcomas

- High-grade tumors with poor prognosis
- Areas of well differentiated liposarcoma and a non-lipogenic (dedifferentiated) component, which has an appearance of a high grade fibrosarcoma or MFH
- Areas with attenuation and SI characteristic of fat-containing well-differentiated liposarcoma
- Mass like areas of non-fatty tissue with higher attenuation as well as lower T1-W and higher T2-W SI



d) <u>Pleomorphic and round cell Liposarcoma:</u>

- Least common subtype of retroperitoneal liposarcoma.
- Nonspecific soft-tissue mass with little if any visible fat.
- Necrosis and hemorrhage may cause signal heterogeneity and nonenhancing areas.
- +C: heterogeneous enhancement



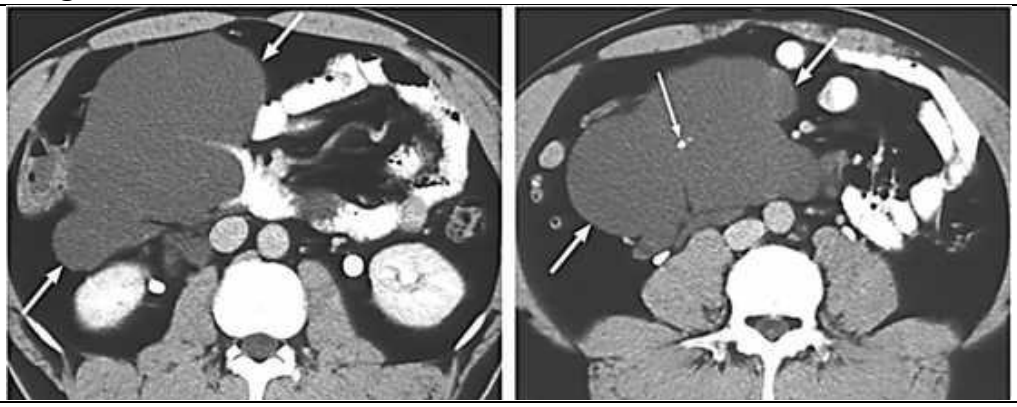
II- Retroperitoneal Cystic Lesions

1) Cystic Lymphangioma:

- Cystic lymphangiomas are uncommon, congenital benign tumors and occur due to failure of the developing lymphatic tissue to establish normal communication with the remainder of the lymphatic system
- Location: perirenal, pararenal, or pelvic extraperitoneal spaces

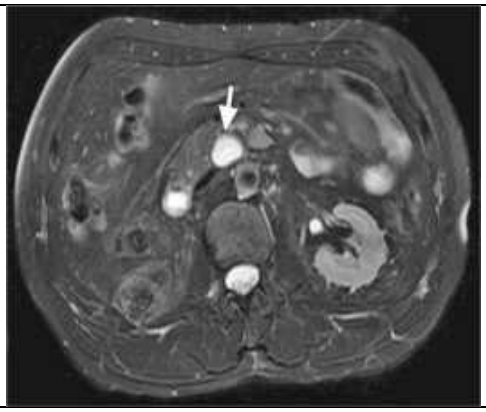
Imaging findings:

- Thin walled, multiseptate cystic mass
- may have wall calcification
- No significant enhancement



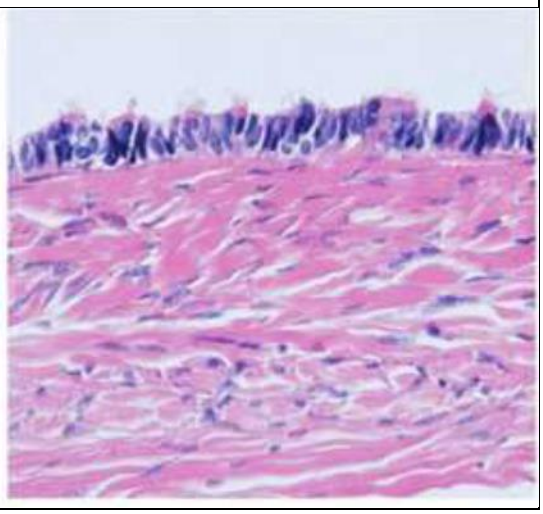
2) Lymphocele

- Lymphoceles are fluid-filled cysts without an epithelial lining that occur after pelvic or retroperitoneal lymphadenectomy or renal transplant surgery



3) Mullerian Cyst:

- Mullerian cyst of the retroperitoneum is an extremely rare disease that is thought to be a subtype of urogenital cyst.
- Urogenital cysts arise from vestiges of the embryonic urogenital apparatus



4) Urinoma:

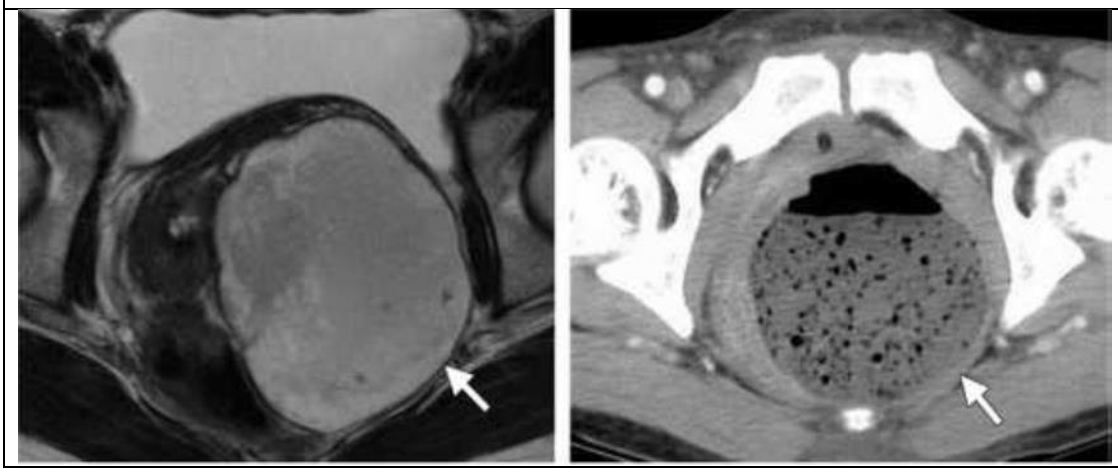
- Urinoma is an encapsulated collection of chronically extravasated urine.
- Both obstructive causes and non-obstructive causes (including abdominal trauma and injury to the collecting system during surgery or diagnostic instrumentation) can lead to urinary extravasation

5) Hematoma:

- Retroperitoneal hematoma may be associated with trauma, ruptured abdominal aortic aneurysm, anticoagulation therapy, or blood dyscrasia.

6) Tailgut Cyst:

- Tailgut cysts are rare congenital multicystic lesions that arise from vestiges of the embryonic hindgut and occur between the rectum and sacrum.

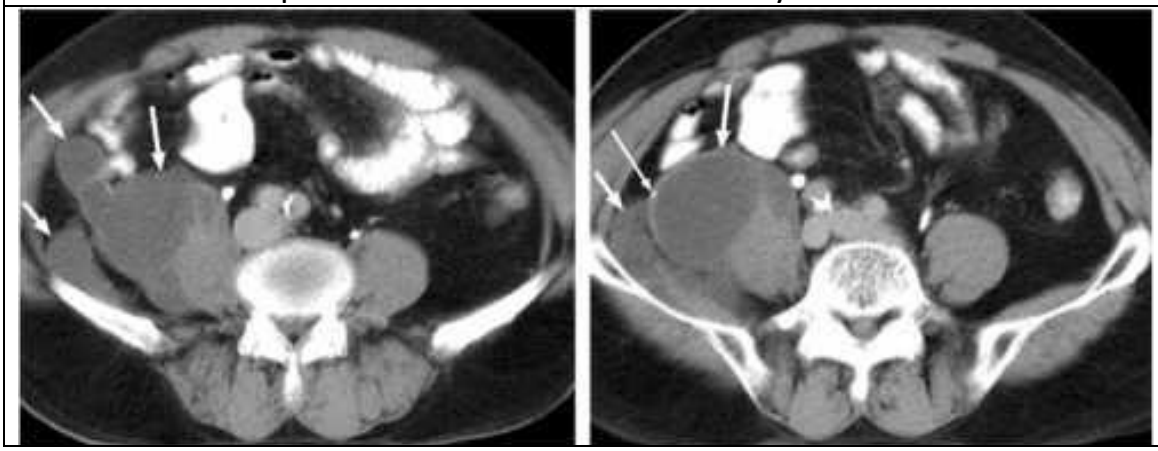


7) Pseudomyxoma Retroperitonei:

- Pseudomyxoma retroperitonei is caused by the rupture of a mucinous lesion in the retrocecal appendix

Imaging findings:

- Multicystic masses with thick walls or septa that displace and distort adjacent structures
- Curvilinear or punctate mural calcifications may also occur

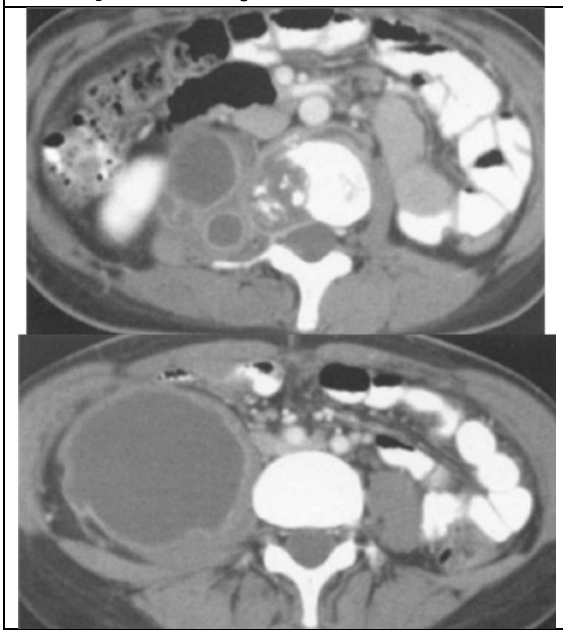


8) Retroperitoneal Lymphangioleiomatosis

Tubers Sclerosis

- Renal: cysts, AML, RCCa
- Liver: cysts, AML
- Retroperitoneal LAM = Retroperitoneal cystic mass; may rupture and cause chylous ascites.
- Retroperitoneal perivascular epithelioid tumor.
- Cardiac Rhabdomyoma
- Chest LAM.
- CNS: Cortical tubers – Subependymal nodules – SEGA – WM.

9) Retroperitoneal Abscess (Pot's Disease)



III- Retroperitoneal Neurogenic Tumors

1) Schwannoma

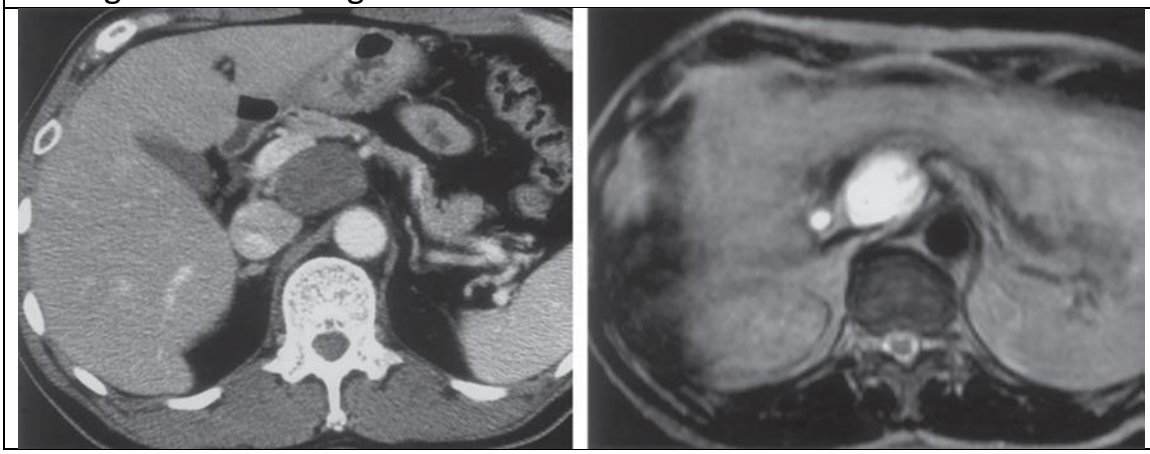
- Is the most common tumor of peripheral nerves

2 different components:

- Antoni type A areas are highly cellular,
- Antoni type B areas are cystic and oedematous

- A well circumscribed fusiform, round, or oval masses.
- Small schwannomas tend to be homogeneous
- Larger schwannomas can show a spectrum of degenerative changes
- Myxoid tissue is hyperintense on T2-weighted images
- Cellular tissue is hypointense on both T1- and T2-
- Solid fibrous tissue enhances

- Larger schwannomas are more likely to undergo degenerative changes, including: cyst formation (in up to 66%), calcification, hemorrhage, and hyalinization.
- Ancient schwannoma refers to a longstanding lesion with advanced degenerative changes



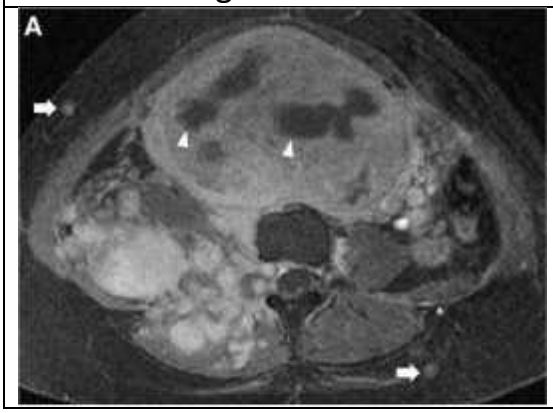
2) Neurofibroma

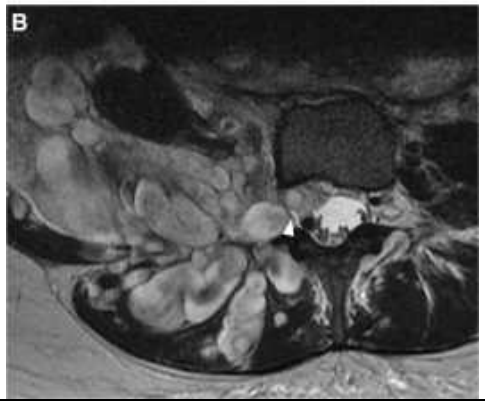
- Benign tumors of nerve sheaths of peripheral nerves
- 5% of all benign soft tissue neoplasms

- 1/3 of patients with a solitary neurofibroma have NF-1
- Almost every patient with multiple or plexiform neurofibromas has NF-1

Imaging findings:

- Homogeneous, smooth, rounded mass.
- CT: hypodense
- T1: Low signal
- T2: High signal
- T2 Target sign = central area of low-intermediate SI fibrous tissue + surrounded by peripheral high SI myxoid tissue
- +C: Homogenous enhancement – Target like central enhancement





Schwannoma	Neurofibroma
Heterogeneous attenuation and signal intensity	Relatively homogeneous
Eccentric position in relation to the parent nerve	Centered on and contiguous with the parent nerve
Low-signal-intensity capsule on MR imaging	Non encapsulated
Composed of Antoni A (cellular) and Antoni B (myxoid) components	Composed of nerve sheath cells, Collagenous bundles, and myxoid component
Nerve-sparing surgery is possible	Resection involves excision of the parent nerve
Malignant degeneration is rare	Plexiform neurofibroma may degenerate into MPNST

3) Paraganglioma

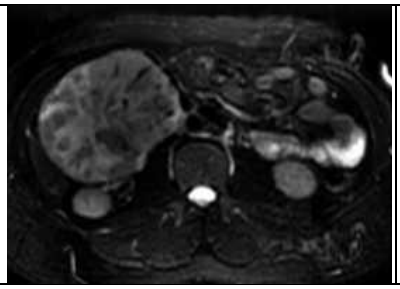
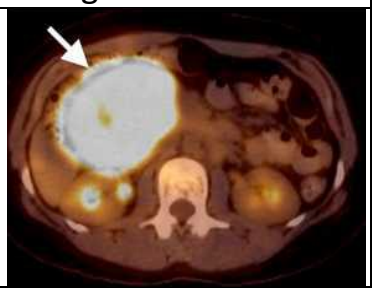
- Paragangliomas sometimes called extra-adrenal pheochromocytomas.
- Rare neurogenic tumors
- Arise from highly vascularized specialized neural crest cells called paraganglia that are symmetrically distributed along the aortic axis in close association with the sympathetic chain in the neck, chest, abdomen, and pelvis.
- The largest collection of paraganglia includes the paired organs of Zuckerkandl that overlie the aorta at the level of the inferior mesenteric artery.

- 10% of pheochromocytomas are extra-adrenal in location and most often arise in the retroperitoneum from the organs of Zuckerkandl.
- 10% of paragangliomas are familial, occurring in conditions such as multiple endocrine neoplasia (MEN) types IIA and IIB and neuroectodermal syndromes such as tuberous sclerosis (TS), neurofibromatosis type I (NF-1), and von Hippel- Lindau syndrome (VHL)
- 10% of Paragangliomas multicentric.

<u>Paragangliomas may be functional or nonfunctional:</u>

- Nonfunctional abdominal paragangliomas present with nonspecific symptoms and signs and are rarely diagnosed as such prior to surgery.
- Functional paragangliomas may cause chronic or intermittent hypertension, headaches, or palpitations, and elevated urinary catecholamines are detected.

- A well-circumscribed, lobular, or round soft tissue masses.
- Hypervascular tumors that enhance briskly
- Punctate calcification 15%
- Focal areas of high attenuation due to acute hemorrhage

4) Ganglioneuroma

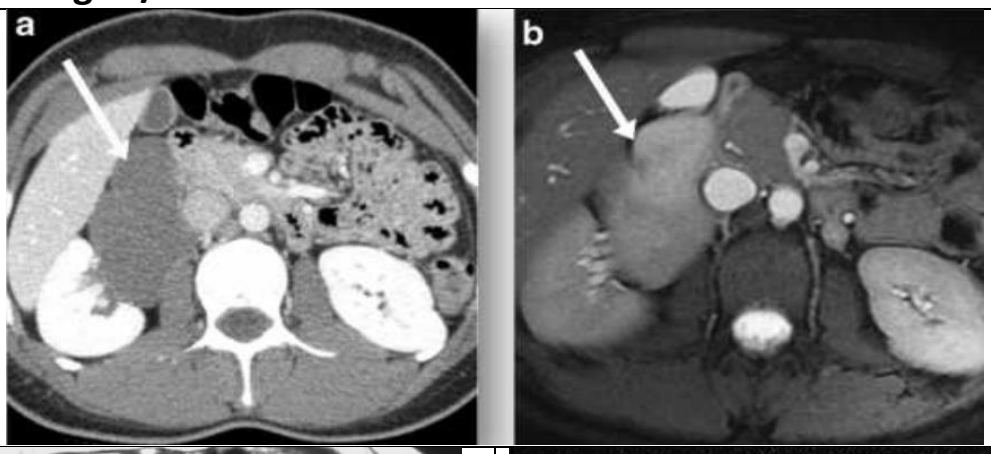
- Uncommon benign neurogenic tumors
- Arise from sympathetic ganglia
- Represent 1–2% of all primary retroperitoneal tumors
- Age: Children and young adults

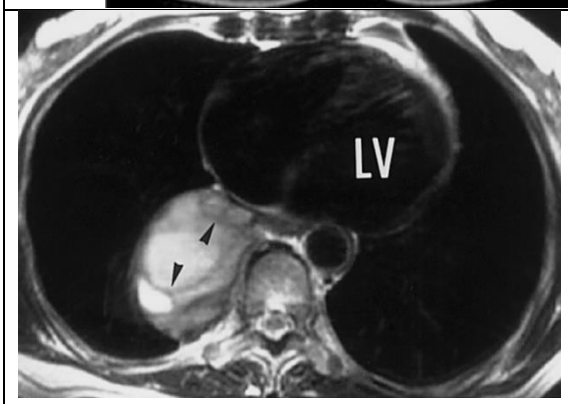
Location:

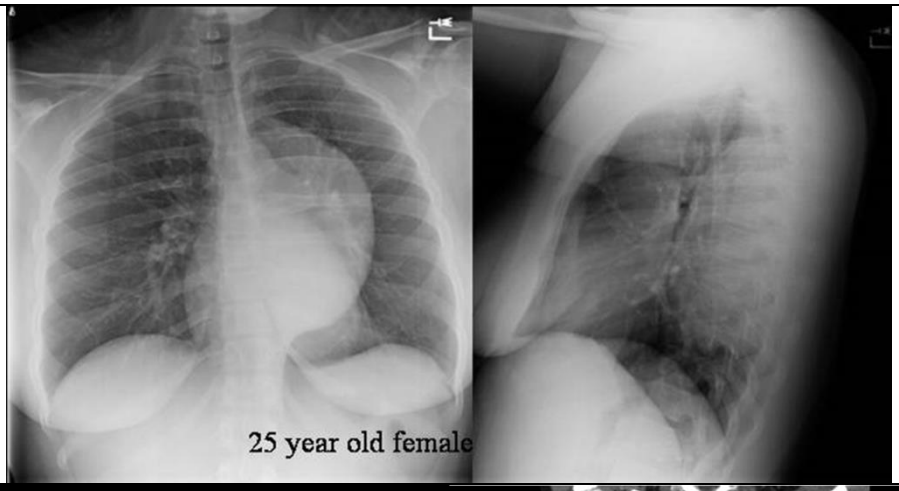
- **Posterior mediastinum (39–43%)**
- **Retroperitoneum (32–52%)**
- **Neck and pelvis (8–9%)**

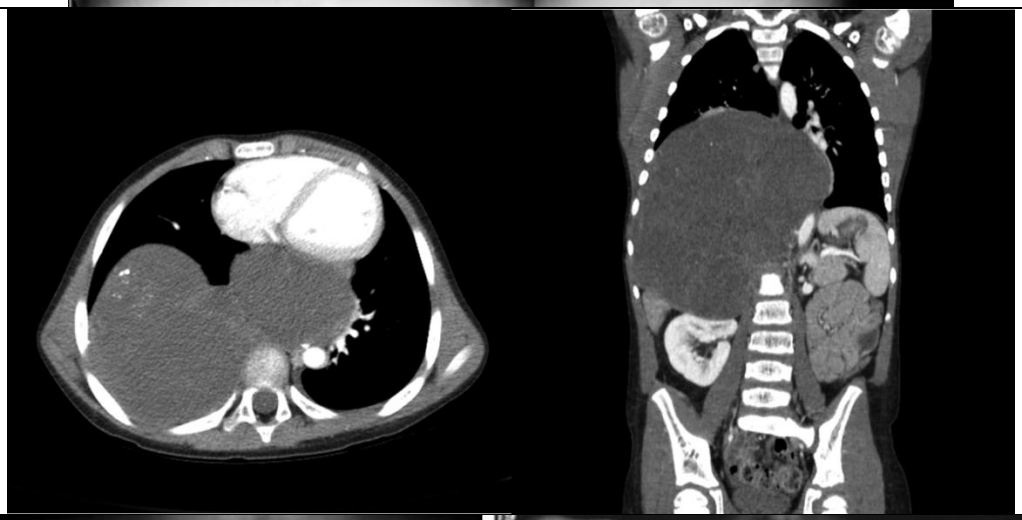
Imaging findings:

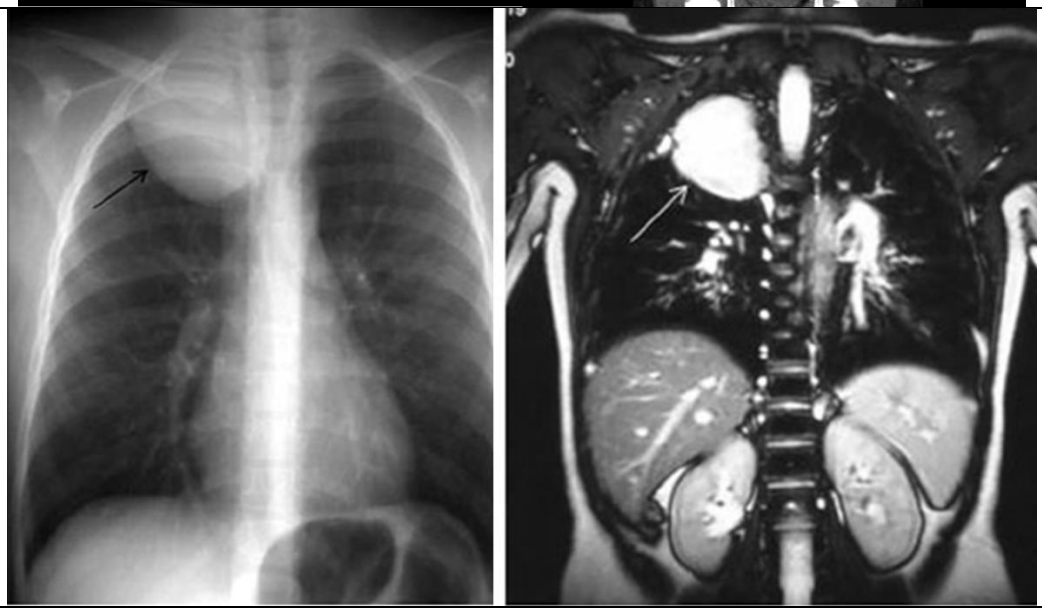
- A well circumscribed oval, crescentic, or lobulated paravertebral mass
- CT: hypodense ± Calcifications
- T1: Low signal
- ***T2: High signal***
- ***T2 whorled appearance:*** low signal interlacing bundles of longitudinal and transverse Schwann cells or to collagen fibers
- **+C: Slight / mild enhancement**






25 year old female





5) Ganglioneuroblastoma and Neuroblastoma

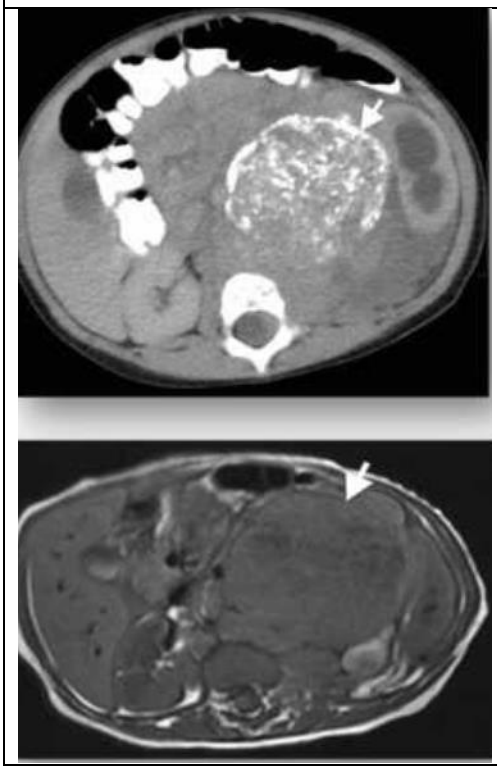
- Ganglioneuroblastoma most often develops in children 2–4 years old.
- Neuroblastoma most commonly occurs in the first decade of life

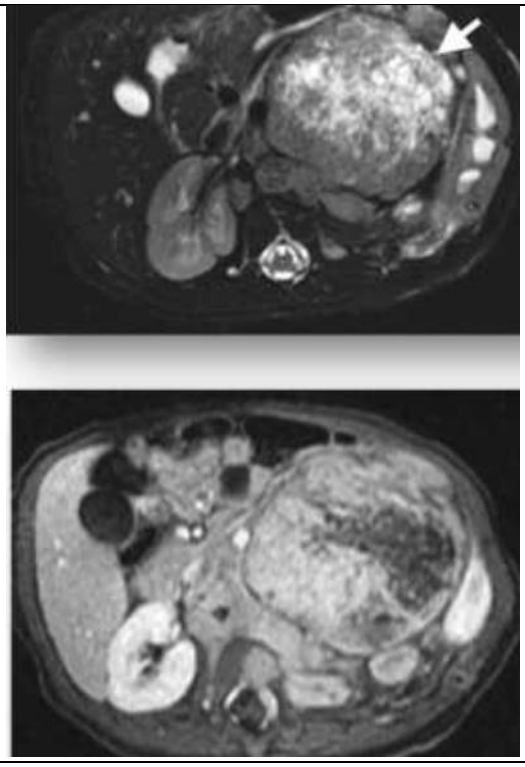
- Neuroblastoma is the third most common pediatric malignancy, after leukemia and central nervous system tumors

- Two-thirds of neuroblastomas are located in the abdomen:
  - 2/3 adrenal gland
  - 1/3 extra-adrenal retroperitoneum

Imaging findings:

- Ill defined lesion
- encasement of vessels without vascular invasion
- Extension into the spinal canal (extradural space)
- Tumoral calcifications





6) Malignant Peripheral Nerve Sheath Tumor (MPNST)

- Malignant tumors that arise from or differentiate toward cells of the nerve sheaths of peripheral nerves
- 5–10% of soft tissue sarcomas.
- MPNST occur in 2–5% of patients with NF-1 and arise from pre-existing neurofibromas, usually after a latent period of at least 10 years.
- 50% of patients with MPNST have NF-1.
- 10–20% of MPNSTs are related to prior radiation exposure, occurring after a latent period of more than 15 years.

Clinical suspicious for MPNST:

- Unexpected growth of a pre-existing neurofibroma, especially a plexiform neurofibroma
- Pain, particularly if spontaneous and unremitting.

Imaging finding raise suspicion of MPNST:

- Large ill defined lesion
- Heterogeneous masses with central necrosis or calcification.
- Rapid enlargement in size of a tumor mass.
- Soft tissue invasion
- Bone erosion or destruction

IV- Retroperitoneal Lymphoma

- Lymphoma is the most common retroperitoneal malignancy,.
- 33% of all primary retroperitoneal masses

Hodgkin's lymphoma (HL)

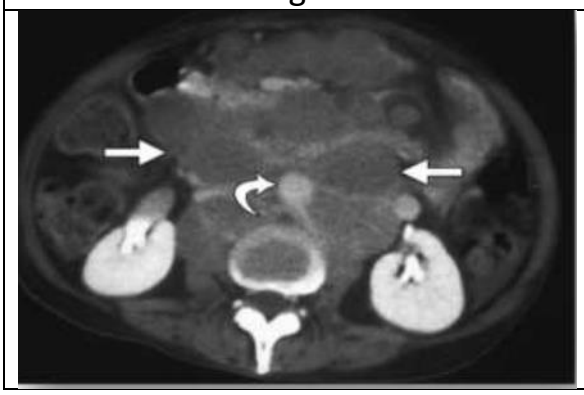
- Bimodal age distribution with peak incidence in the second decade and a smaller peak in the sixth decade.
- Abdominal HL tends to involve the spleen and mediastinum, with involvement of para-aortic nodal groups in 25% of cases

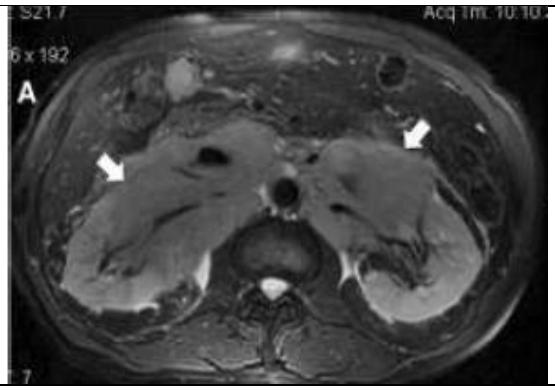
Non-Hodgkin's lymphoma (NHL):

- Age: 4^{th} – 7^{th} decade
- NHL tends to involve extranodal sites, such as the liver, spleen and bowel, as well as discontinuous nodal groups, with para-aortic nodes affected in 55% of cases

Imaging findings:

- A well defined para-aortic or pelvic lobulated irregular masses
- Infiltrative mantle-like mass encasing aorta or IVC, extending between without compressing them
- Aorta and IVC can be anteriorly displaced
- ***"floating aorta" or "CT angiogram" sign***
- Homogeneous attenuation and signal
- T1: iso – hypo
- T2: iso - hyper
- +C: Mild homogenous enhancement.





V- Retroperitoneal Metastatic Lymphadenopathy

Common primary malignancies:

- Renal cell, cervical, testicular, and prostatic carcinomas

Imaging differentiation between metastatic and reactive lymph nodes is based:

- Size criteria (short axis dimension) is location based:
  - Retrocrural space > 6 mm
  - Retroperitoneum > 10 mm
  - Pelvis > 15 mm
- Central necrosis
- Rounded shape
- Infiltration of the surrounding structures

VI- Retroperitoneal Sarcoma

- Sarcomas are rare neoplasms of mesenchymal origin
- <1% of all malignancy in adults
- 15% of which occur in the retroperitoneum
- Retroperitoneal sarcomas are most common in men > 60 years

Histological types:

Most common:

- Liposarcoma (40% of cases) (Most common)
- Leiomyosarcoma (30% of cases)
- Malignant fibrous histiocytoma (MFH) (15% of cases)

Less common:

- Angiosarcoma
- Rhabdomyosarcoma
- Synovial cell sarcoma

1) Liposarcoma (Most common) (discussed before)

2) Leiomyosarcoma

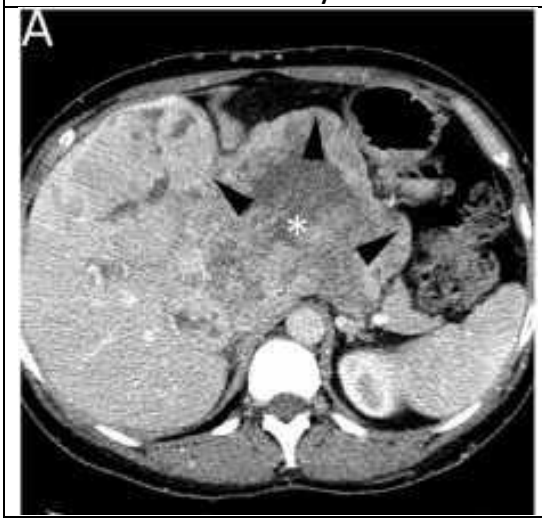
- 2nd most common retroperitoneal sarcoma,
- Age: 5th – 6th decade
- Sex: Female predominance

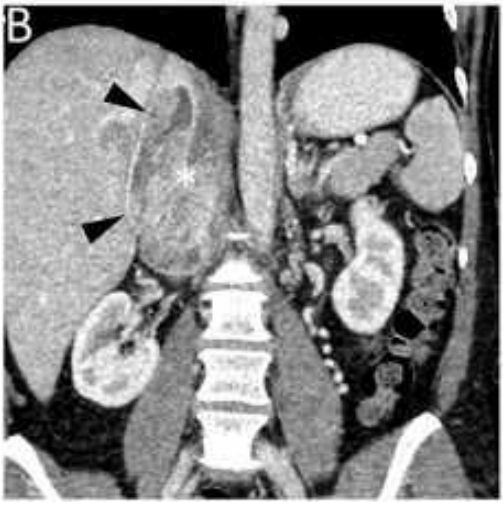
- They arise from smooth muscle elements within the retroperitoneal muscle tissue, blood vessels, or Wolffian duct remnants

Location:

- ***Most common intraluminal venous neoplasm.***
- ***Most common primary tumor of the IVC.***
  - Extravascular (62%)
  - Combination of extra- and intra- vascular components (33%)
  - Intravascular (5%)

- Large, well-circumscribed mass
- Internal areas of low attenuation represent necrosis and cystic degeneration
- T1: low to intermediate
- T2: heterogeneous intermediate-high
- +C: variable delayed enhancement



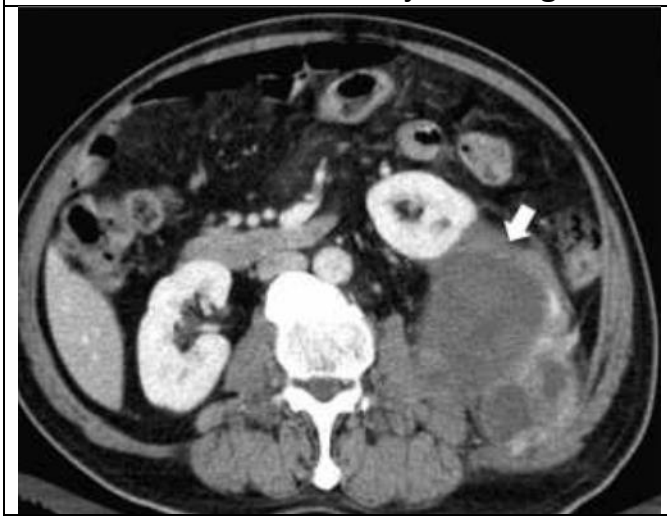


3) Malignant Fibrous Histiocytoma (MFH)

- 3rd most common primary retroperitoneal sarcoma
- Age: 5th – 6th decade
- Sex: Predominantly affect men

Imaging findings:

- Non-specific
- Large, wellcircumscribed soft tissue masses
- Areas of necrosis and hemorrhage
- +C: enhance heterogeneously.
- Direct invasion into adjacent organs may occur



VII- Retroperitoneal Fibrosis (RPF)

- RPF is a rare collagen vascular disease
- Age: 4^{th} – 6^{th} decades
- Sex: most common in men

❖ **Primary (idiopathic) 2/3 of cases:**

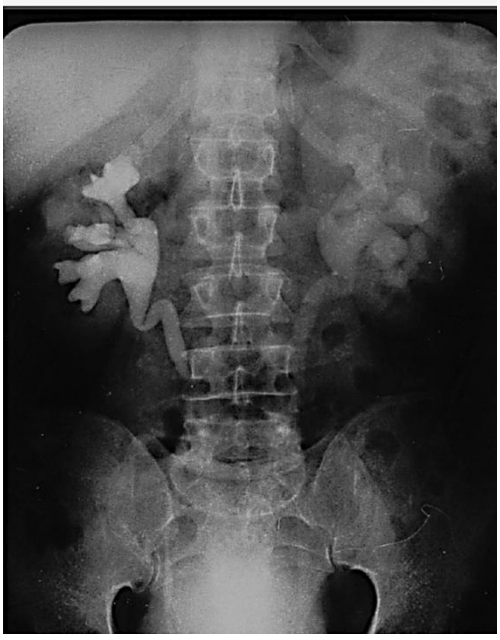
- Immune reaction to antigens contained within atheromatous plaques of the abdominal aorta

❖ **Causes of secondary RPF**

- Drugs: Methysergide, B blocker, hydralazine, ergotamine, LSD
- Diseases that stimulate desmoplastic reaction:
- Malignant tumors, Metastases, Hodgkin, Carcinoid tumor,
- Hematoma, Radiation, Retroperitoneal injury, Surgery,
- Infection, Urinary extravasation

IVU => Classic Triad :-

- Delayed renal contrast excretion with unilateral or bilateral hydronephrosis proximal hydroureter secondary to ureteral involvement,
- Medial deviation of the middle third of both ureters,
- Tapering of the ureteral lumen at the L4–L5 vertebral level



Imaging findings:

- Ill-defined soft tissue mass surrounds the infrarenal portion of the abdominal aorta, IVC, ureters and iliac vessels.
- Ureteral medial deviation and obstruction
- Not anterior displacement of aorta or IVC.
- Sparing of retroaortic prevertebral space

❖ **Acute stage = Active inflammation**

+C: Avid enhancement

T2: High signal

❖ **Late stage = Predominant fibrosis**

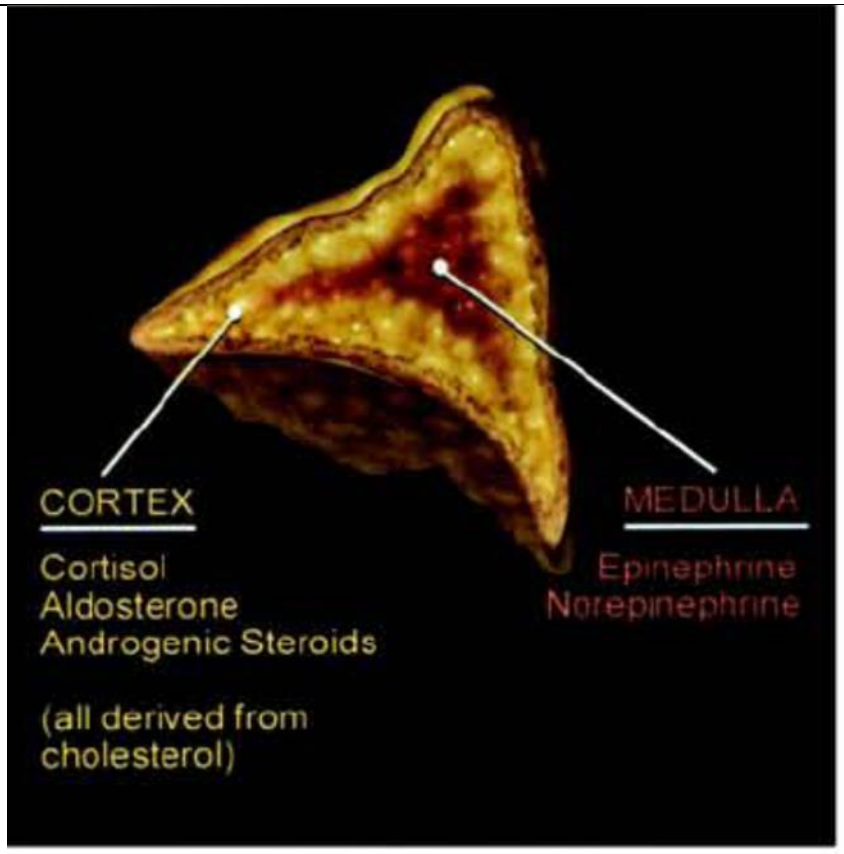
+C: mild or no enhancement

T2: Low signal

Idiopathic/Benign RPF	Malignant RPF
• Infrarenal • Spares the posterior aspect of the great vessels and • Not cause anterior vascular displacement. • Medial displacement of ureters • Low signal intensity on T2 is highly suggestive of benign RPF in the late inactive stage	• Supra/Infrarenal • Anterior displacement of the aorta and IVC • Nodular aspect • Mass effect on neighboring structures • high T2 signal intensity cannot be used to differentiate between malignant and early-stage idiopathic RPF

a.
b.
c.
d.
A
B
C
D

Adrenal Gland

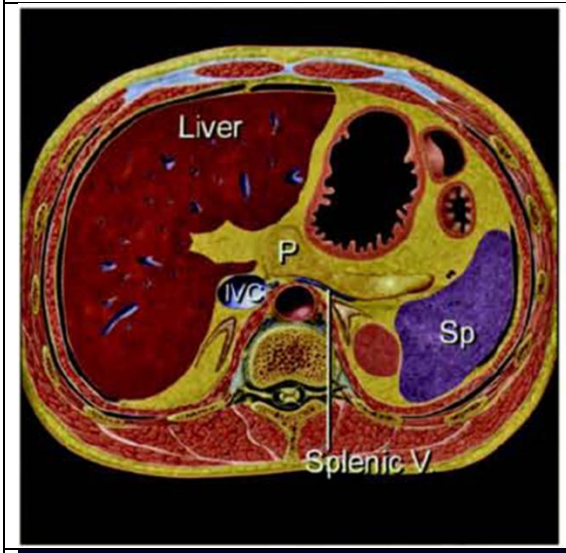


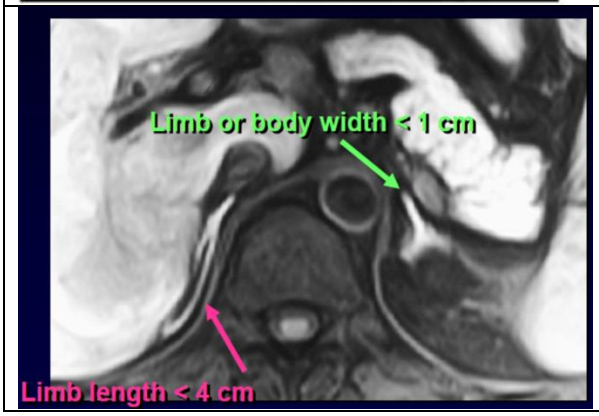
Anatomy of Adrenal Gland

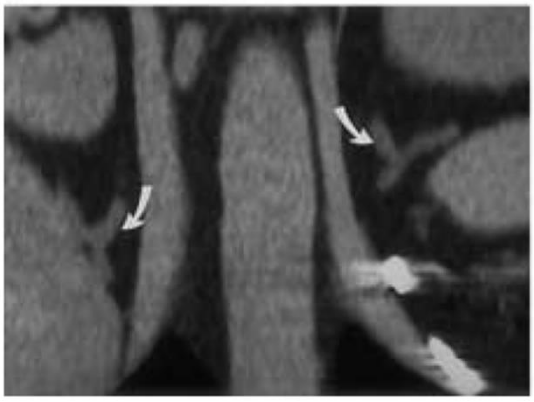
- The adrenal glands are V or inverted-Y shaped retroperitoneal organs lying in the perirenal space within the perinephric fascia

- The adrenal glands are histologically composed of cortex and medulla
  - Cortex: produces cortisol, aldosterone and steroids
  - Medulla: produces epinephrine and norepinephrine

- Right adrenal is suprarenal, lies lateral to diaphragmatic crus, medial to liver, and touches the back of the IVC
- Left adrenal is usually ventral to upper pole of left kidney, dorsal to the splenic vein and pancreas





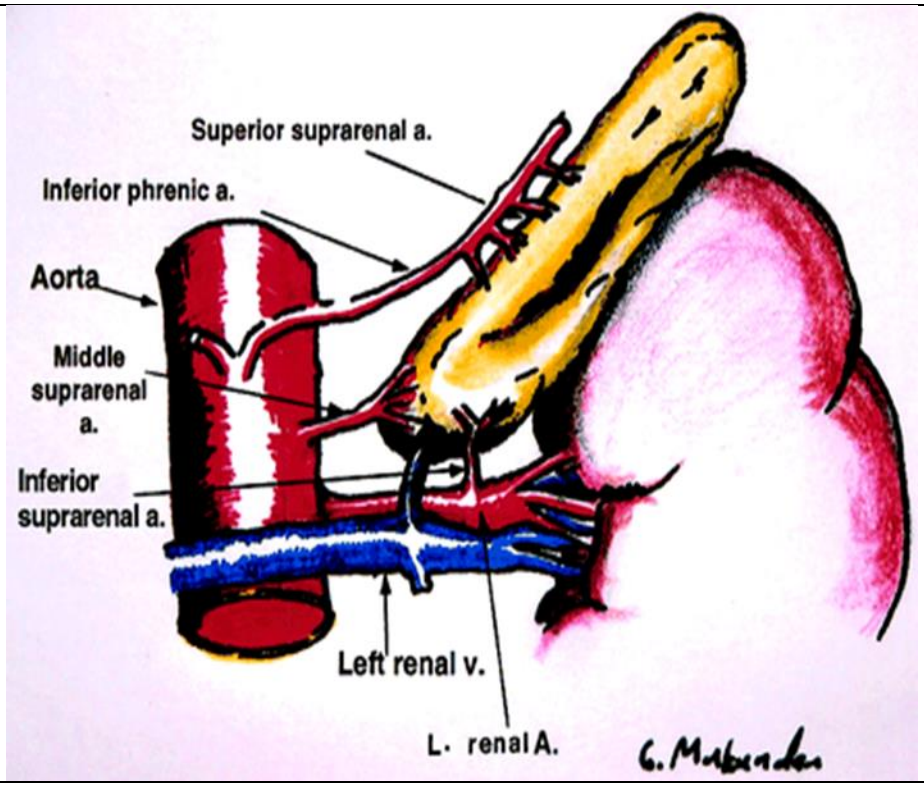


Arterial supply :

Abdominal aorta → Inferior phrenic a. → Superior suprarenal artery
Abdominal aorta → Middle suprarenal artery
Renal artery → Inferior suprarenal artery

Venous Drainage:

Right suprarenal vein → drain into IVC
Left suprarenal vein → left renal vein



Adrenal Lesions

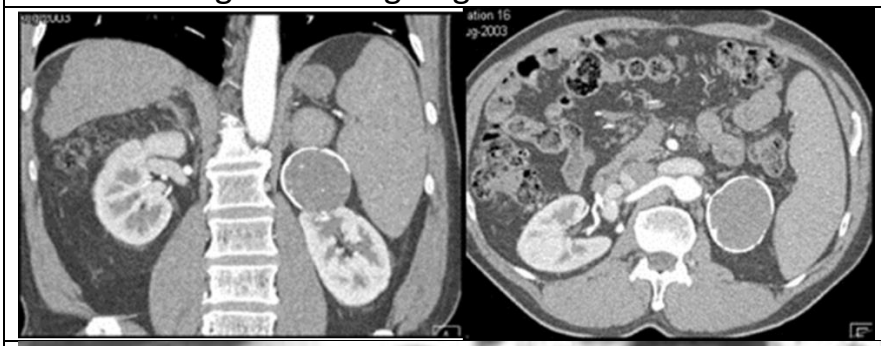
Adrenal Cyst
Fat => Adrenal Myelolipoma
Solid lesions: • **Adenoma** • **Pheochromocytoma** • **Neuroblastoma** • **Metastasis** • **Adrenocortical carcinoma** • **Lymphoma**
Adrenal Hyperplasia
Adrenal Calcification
Adrenal Hemorrhage

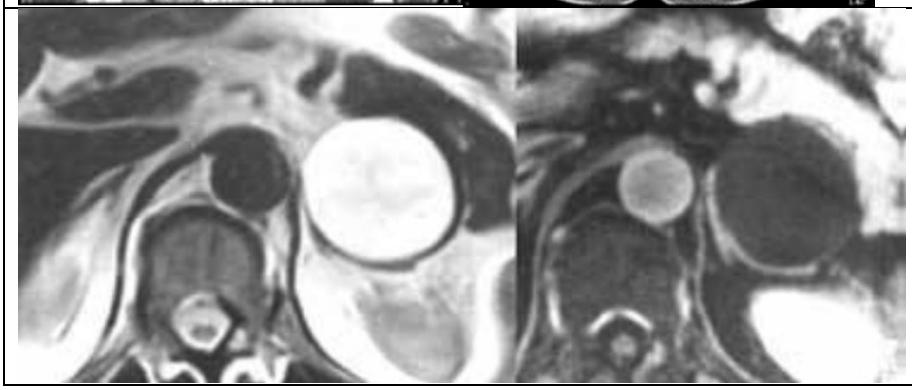
Adrenal Cyst

- **<u>Endothelial lining (45-48%)</u>**
  - Lymphangioma
  - Hemangioma
- **<u>Pseudocyst (39-42%)</u>**
  - Prior hemorrhage or infarction
  - Cystic degeneration
- **<u>Epithelial lining: True cyst (9-10%)</u>**
  - Glandular or retention cyst
  - Embryonal cyst
  - Cystic adenoma
  - Mesothelial inclusion cyst
- **<u>Parasitic cyst (7%)</u>**
  - Hydatid or echinococcal cyst

Imaging findings:

- Well-defined adrenal lesion. No enhancement.
- CT: water-density ± calcification.
- T1: Low signal. T2: High signal.





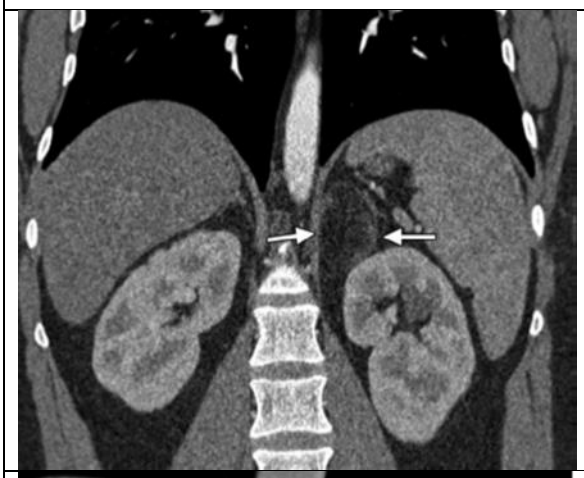
Adrenal Myelolipoma

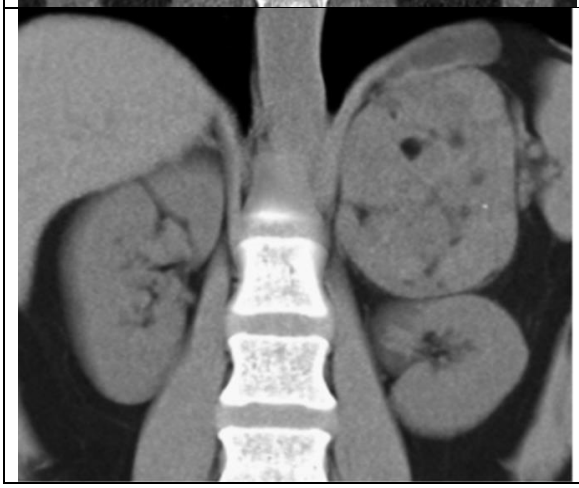
- A relatively uncommon benign tumor composed of hematopoietic tissue and mature adipose that is usually identified incidentally
- Nonfunctioning tumors

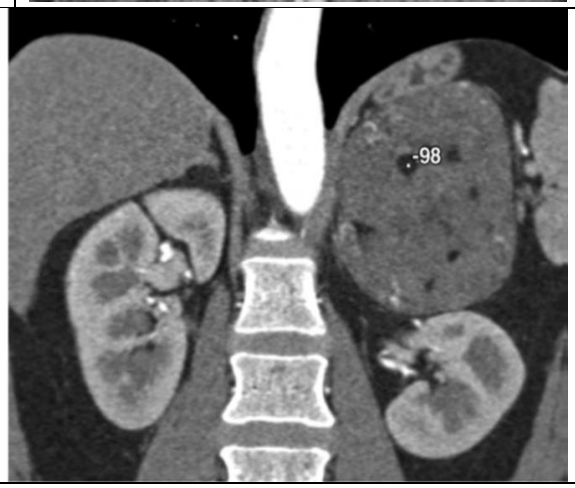
- 60% :- in women
- Size was 2–17 cm

Imaging findings:

- Fatty tissue / foci
- Vascular solid tissue
- Calcification is DIAGNOSTIC







Adrenal Adenoma

- Most common tumor in the adrenal gland.
- The majority of lesions are not functioning.
- 2% of general population have non-hyperfunctioning adrenal adenoma.

Imaging findings:

- Small, 2–3 cm.
- Homogeneous attenuation
- Well-defined
- Clear margins.

CT Imaging Technique:

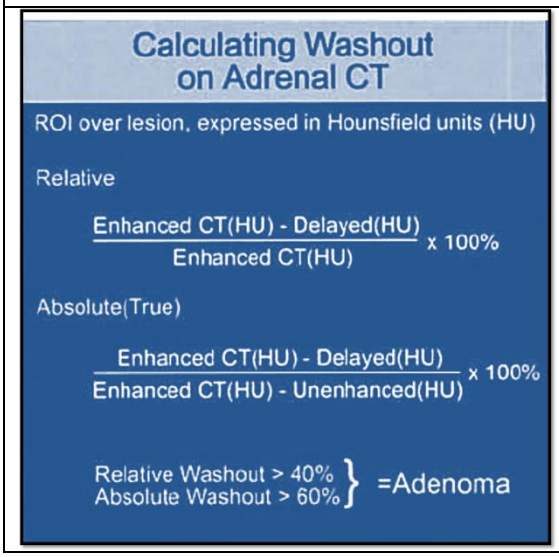
3 mm thick sections
NECT should be done first.
CECT at 60 sec
Delayed images after 15 minutes
Axial images + Coronal or sagittal reconstructions

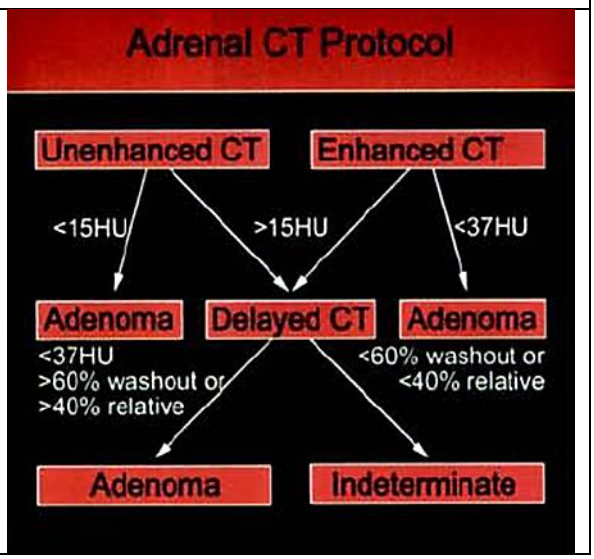
Pre-contrast CT attenuation

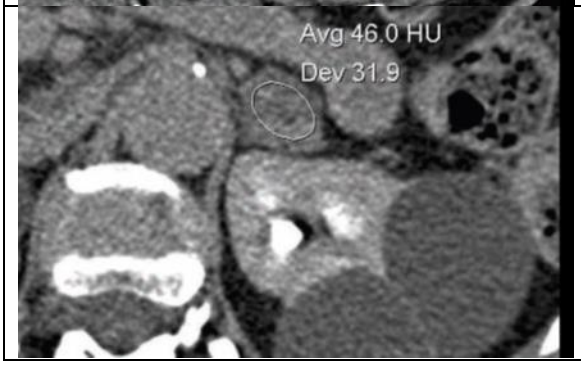
- ***<10 HU => lipid-rich adenomas***
- >10 HU => CT Adrenal Wash-out => lipid-poor adenomas

CT Adrenal Wash-out

- ***Absolute washout APW> 60%***
- If unenhanced CT is not available => Relative washout RPW > 40%


Calculating Washout on Adrenal CT
ROI over lesion, expressed in Hounsfield units (HU)
Relative
Enhanced CT(HU) - Delayed(HU) / Enhanced CT(HU) x 100%
Absolute(True)
Enhanced CT(HU) - Delayed(HU) / Enhanced CT(HU) - Unenhanced(HU) x 100%
Relative Washout > 40%
Absolute Washout > 60%
=Adenoma





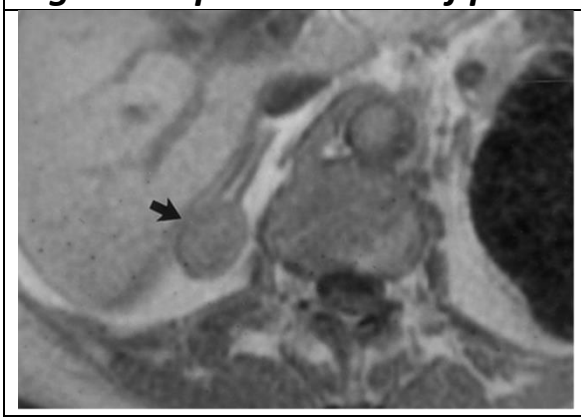
Using absolute washout formula
E - D/E - U:
(112 - 46) / (112 - 16) = 69% washout
>60% washout is diagnostic of an adenoma

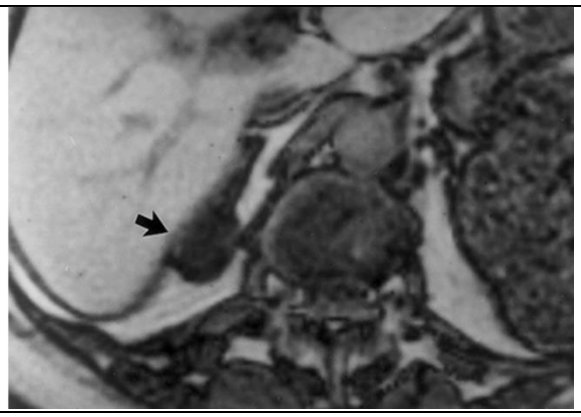
MR IMAGING TECHNIQUE

Conventional T1-weighted spin echo (SE) or gradient-echo
Fat suppresion images to characterize hyperintense lesions on T1WI
Heavy T2-weighted
Chemical shift: In-phase and out-phase

Chemical Shift MRI:

Signal drop-out on out of phase GRE MRI





PHEOCHROMOCYTOMA

- Pheochromocytomas are paragangliomas arising from adrenal medulla.
- They are hormonally active in 90% of cases.
- Unilateral adrenal mass

Clinical Picture:

- New onset, refractory, paroxysmal or recently exacerbated hypertension
- Clinical: headache, palpitations and excessive sweating.

Laboratory Tests:

- Plasma catecholamine levels:
  - Metanephrine - Normetanephrine
- Urine assay for catecholamine metabolites:
  - Metanephrine - Normetanephrine
  - Dopamine
  - Vanillylmandelic acid (VMA)

Role of 10%	10% Syndromes
10% Malignant **10% Hormonally inactive** **10% Bilateral** **10% Extra-adrenal** **10% Syndromatic**	• Multiple Endocrine Neoplasia (MEN 2) • Von Hippel–lindau Syndrome • Neurofibromatosis • Tuberous Sclerosis • Sturge-weber Syndrome • Carney Triad: Pulmonary Chondroma, Gastric Leiomyosarcoma, Pheochromocytoma
10% Extra-adrenal	**Paragangliomas in H&N**
• Along sympathetic chain: neck to urinary bladder • The most common intraabdominal location of a paraganglioma is the organ of Zuckerkandl, located at the aortic bifurcation	• Glomus tympanicum • Glomus jugulare • Glomus vagale • Carotid body tumor

Imaging Findings:

- Well-defined, round, adrenal mass
- ± Areas of high density / high T1 signal (hemorrhage)
- ± Areas of low density (cystic, necrotic)
- ± Areas of curvilinear or mural calcification
- T1: Isointense to muscle & hypointense to liver
- ***T2: Markedly hyperintense (characteristic)***
- C+:
- Characteristic salt & pepper pattern (due to increased tumor vascularity)
    - Salt: Represents enhancing parenchyma
    - Pepper: Represents flow void of vessels
- Porto-venous phase: Marked homogenous enhancement
- Delayed Phase: Washout characteristics are variable, pheochromocytoma may mimic adenoma (ie, APW > 60%, RPW > 40%)

- I-123 MIBG is used for metastatic workup of pheochromocytoma
- Indium-111 pentetreotide (an analog of octreotide) is used as tracer for localization of a paraganglioma.

Neuroblastoma & Ganglioneuroblastoma

- Malignant tumor of primitive neural crest cells
- 3rd most common pediatric malignancy after leukemia/lymphoma and CNS tumors
- Most common extra-cranial solid malignant tumor of childhood.
- 8–10% of all childhood cancers.
- 15% of childhood cancer fatalities

Age:

Neuroblastoma < 3y
Ganglioneuroblastoma 3-10y
Ganglioneuroma > 10y

Location:

- Adrenal medulla (35%)
- Extraadrenal:
  - Abdominal retroperitoneum (30-35%)
  - Posterior mediastinum (20%)
  - Pelvis (2-3%)
  - Neck (1-5%)
  - Metastatic disease with no primary identified (1%)

Staging:

1: Confined to organ of interest (90% survival)
2: Extension beyond organ but not crossing midline (75% survival)
3: Extension crossing midline (30% survival)
4: Distal metastasis (10% survival)
4S: Age < 1 year, metastatic disease confined to skin, liver, and bone marrow (near 100% survival)

Whole body MRI, MIBG scan, Tc99m-MDP bone scintigraphy, FDG-PET/CT assess skeletal and non-skeletal metastasis

Imaging findings:

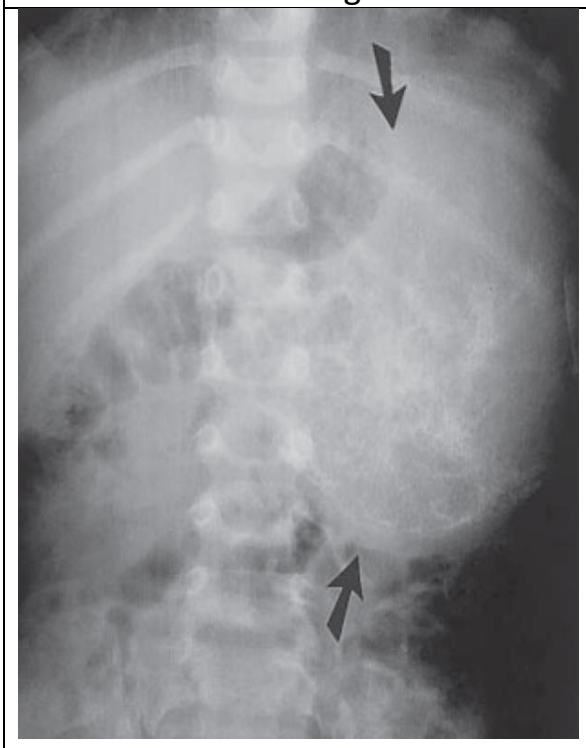
- Calcifications: Common 80% - 90%
- Heterogeneous from necrosis and hemorrhage
- Aggressive tumor with tendency to invade adjacent tissues
- Surrounds and encases vascular structures such as celiac artery, SMA, renal arteries and aorta
- Regional invasion of psoas and paraspinal musculature.
- Spinal canal invasion via neuroforamina

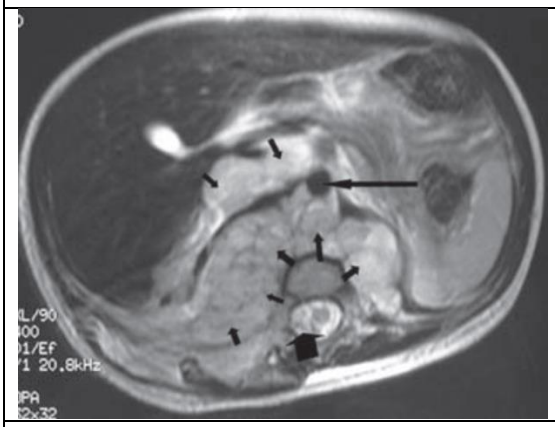
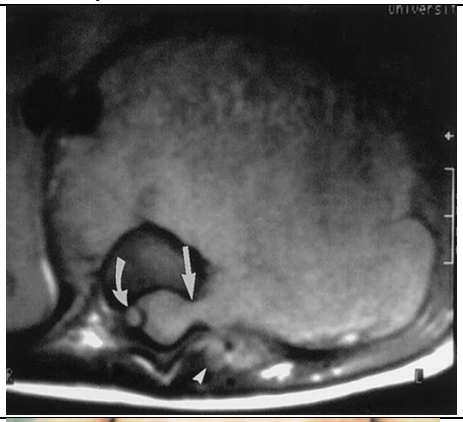
Adenopathy:

- Renal hilum
- Porta hepatis
- Retroperitoneum

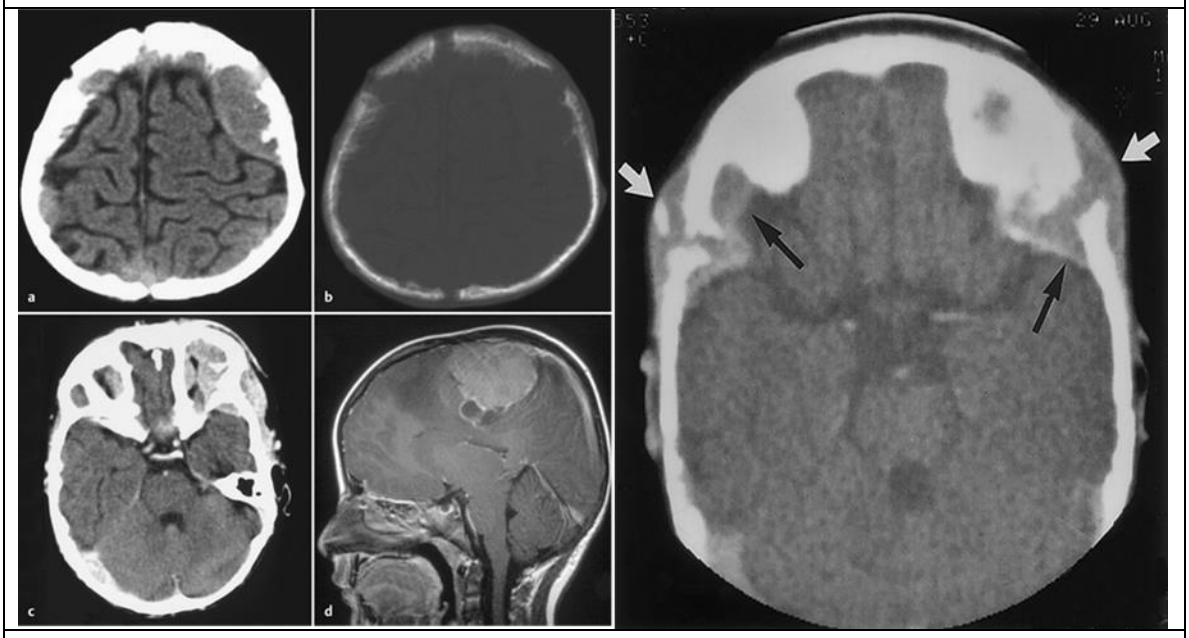
Metastasis:

- Liver metastasis: Low attenuation lesions or diffuse, heterogeneous liver enlargement
- Bony metastasis is classically to the lateral wall of the orbit and to the calvarial causing sutural widening

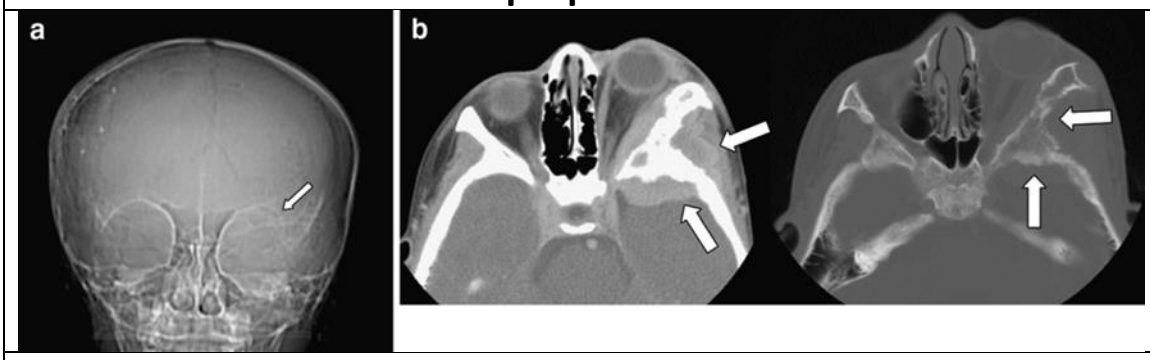


Encasing vessels	Intraspinal extension
Aorta “lifted off” the vertebra	Intraspinal extension
	
4s Blueberry Muffin Syndrome: Multiple bluish skin masses of metastatic NB	
Subcutaneous Nodules	Diffuse Liver Metastasis

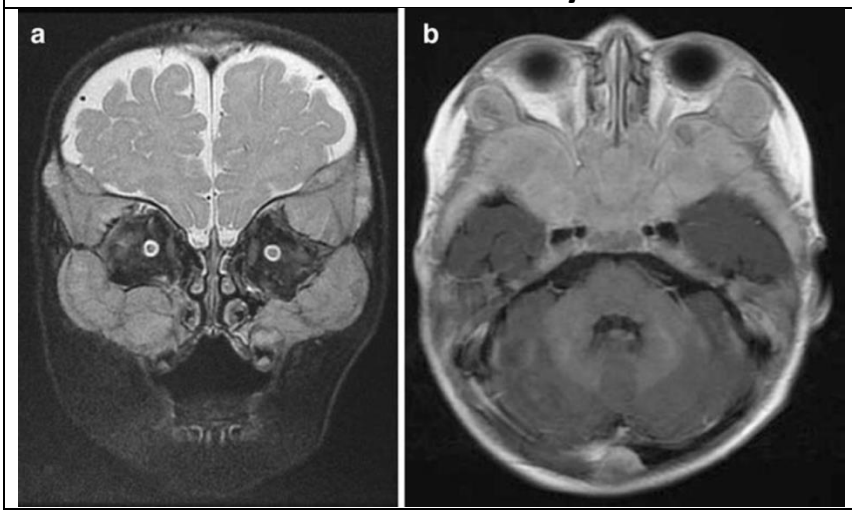
Bone Metastasis => Suture Diastasis



Bone Metastasis => Orbital proptosis



Bone Metastases => Raccoon Eyes



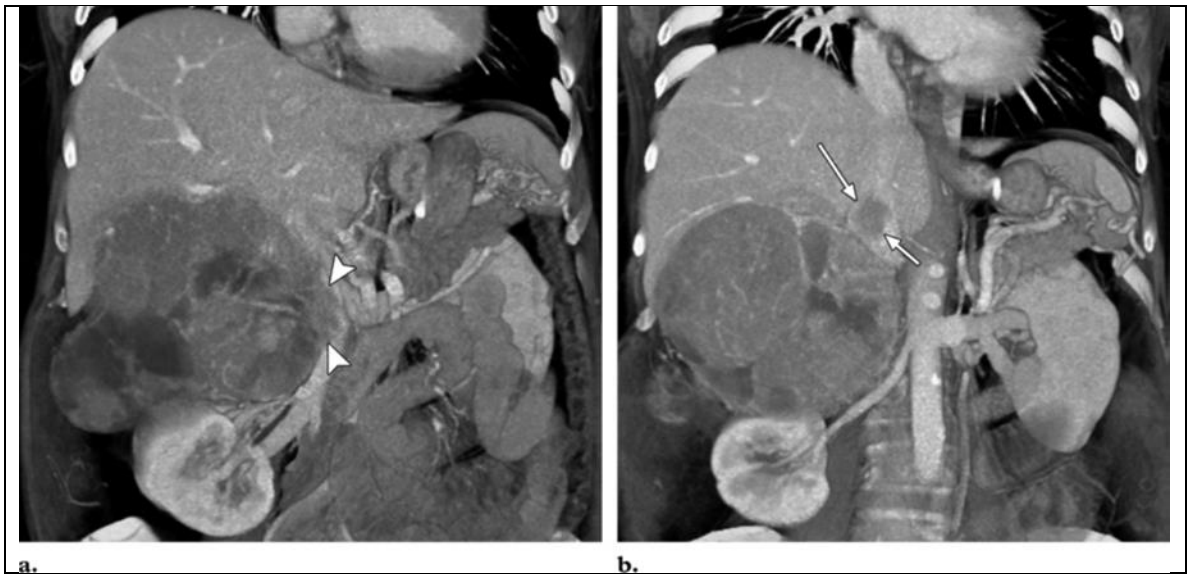
Adrenocortical Carcinoma

- Rare & highly malignant neoplasm of adrenal cortex
- Age: A bimodal peak (1st and 4th decades)
- 55%: functional: Cushing syndrome, feminization, virilization in females

Imaging findings:

- Unilateral, but bilateral in up to 10% of cases
- Large > 4cm
- Calcification is seen in 20-30% of cases.
- Areas of hemorrhage and necrosis
- Heterogeneous density / signal
- Heterogeneous enhancement
- Absolute washout at 15 min < 60%
- Relative washout at 15 min < 40%

- Local spread: regional and paraaortic LNs
- Tumor thrombus => Renal vein, IVC
- Metastatic spread: Lungs, liver, bone

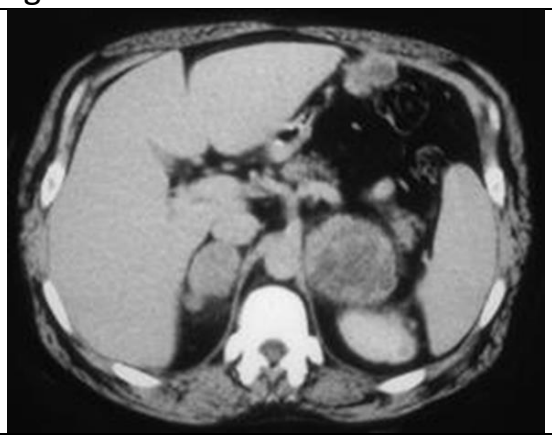


Adrenal Metastasis

- The adrenal glands are 4th most common site of metastasis in the body
- Common in melanoma, lung and breast

Imaging findings:

- Areas of hemorrhage and necrosis
- Heterogeneous density / signal
- Heterogeneous enhancement
- Absolute washout at 15 min < 60%
- Relative washout at 15 min < 40%
- Unilateral or bilateral
- No signal dropout in out of phase images



Adenoma

- Small (less than 4 cm)
- Homogenous
- Smooth outline
- Signal loss on out of phase images
- Mild homogenous enhancement with early washout >50%

Metastasis

- Large
- Heterogenous
- Irregular contour
- No signal loss on out of phase images
- Heterogenous enhancement with delayed washout <50%

ADRENAL HYPERPLASIA

Inheritance:

- Congenital
  - Congenital adrenal hyperplasia
  - Primary pigmented nodular adrenal dysplasia
- Acquired adrenal hyperplasia

Morphology:

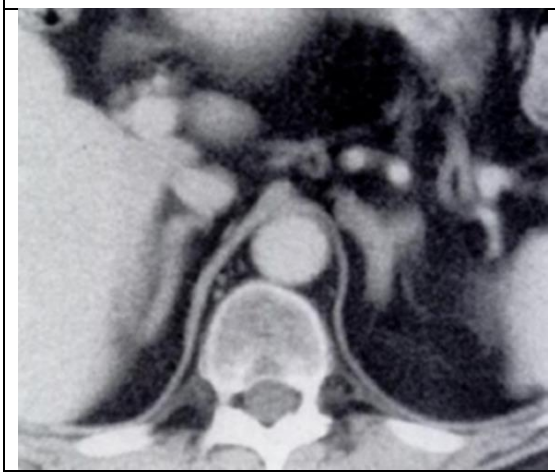
- Micronodular adrenal hyperplasia
- Macronodular adrenal hyperplasia
  - Adrenocorticotropin independent macronodular adrenocortical hyperplasia (AIMAH)

Associations:

- **80% of Cushing**
- **20% of Conn**

Imaging findings:

- Enlarged limbs of one or both adrenal glands >10 mm thick
- Cerebriform" appearance = redundant folds of cortex and medulla creating a pattern that resembles sulci and gyri in the brain.
- Normal adrenal morphology maintained
- Nodular or uniform

Bilateral adrenal hyperplasia in Cushing syndrome.	AIMAH (ACTH Independent macro-nodular adrenal hyperplasia) with Cushing syndrome.
	

Adrenal Calcification

A. Hemorrhage:

- Sepsis : Waterhouse-Friderichsen syndrome
- Blunt abdominal trauma
- Neonatal asphyxia
- Coagulopathy
- Infants : calcification seen soon after haemorrhage (1 - 2 weeks)
- Addison disease

B. Wolman disease

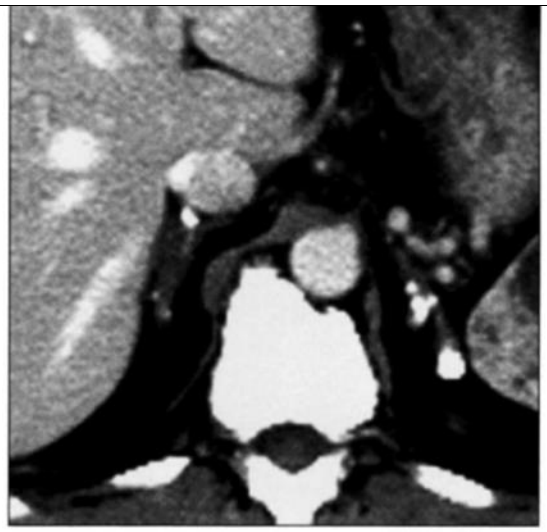
- A rare AR lipid metabolism caused by reduced levels of lysosomal acid lipase that causes bilateral adrenal calcification
- It occurs in infancy and is fatal in most cases

C. Infection

- Tuberculosis – Histoplasmosis

D. Adrenal tumours

- Adrenal metastases - especially melanoma
- Neuroblastoma – Myelolipoma - Adenoma
- Adrenocortical carcinoma
- Pheochromocytoma



Adrenal Hemorrhage

- Adrenal hemorrhage is an uncommon cause of adrenal mass
- Adrenal hemorrhage is less common in children and adults than in neonates.
- Bilateral adrenal hemorrhage should lead to an evaluation for a coagulopathy.
- Adrenal insufficiency as a result of adrenal hemorrhage is usually due to bilateral adrenal involvement. Adrenal insufficiency is uncommon and is usually self-limited.
- Adrenal hemorrhage is also a marker of hypotension and is seen in critically ill patients.
- There is an association of adrenal hemorrhage with adrenal and renal vein thrombosis.

- Unilateral in 80% of cases: Right (85%) >>> left (15%)
- Bilateral in 20% of cases

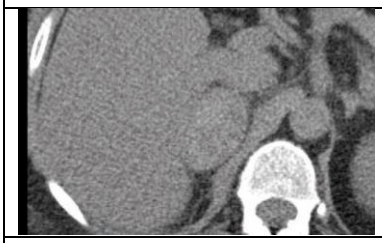
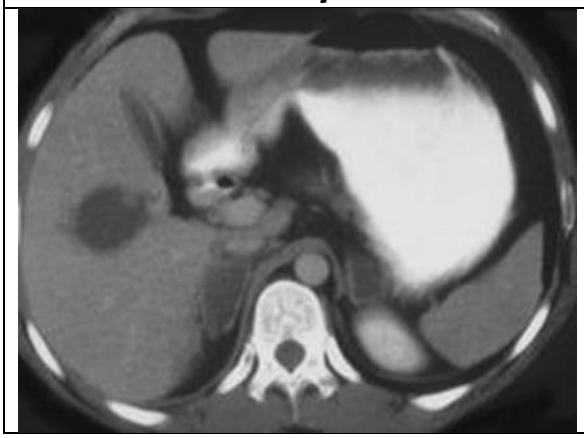
Imaging Findings:

NCCT:

- Acute haematoma is hyperdense.
- With aging blood, it becomes hypodense and may persist as pseudocyst.

MRI:

- In the subacute stage (7 days to 7 weeks after onset): Hyperintense on T1W and T2W images compared with liver.
- In the chronic stage (which typically begins 7 weeks after onset): Hypointense rim is present on T1W and T2W images because of hemosiderin deposition
- +C: No enhancement.

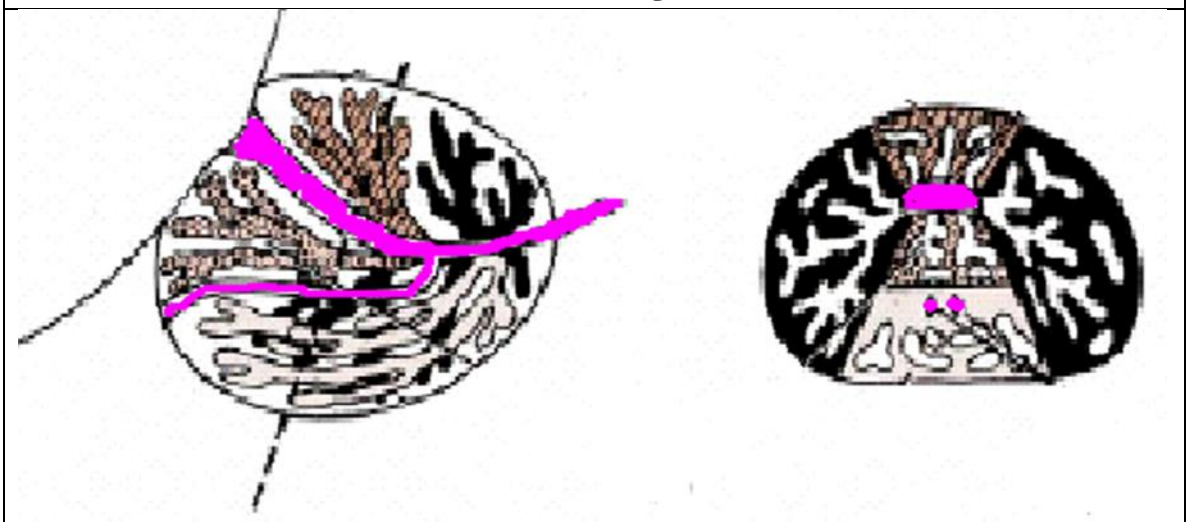
Adrenal Hyperdense lesion		
NCCT	60 sec	15 min
		
Adrenal Pseudocyst	**Marginal calcifications**	
		

Male Genital System

A. Prostate

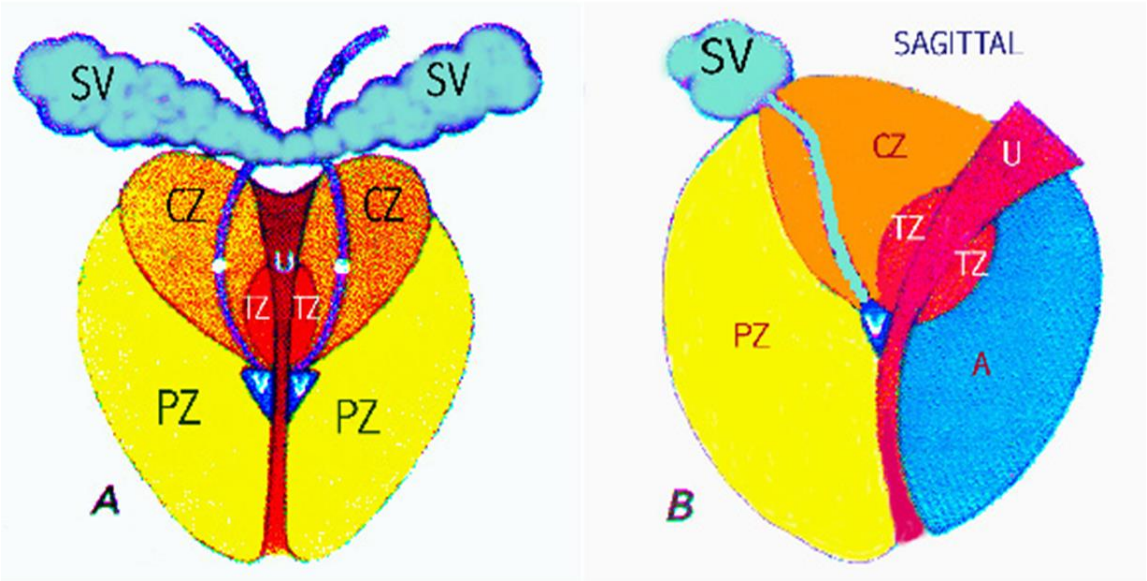
Prostate Anatomy

❖ *Lobar Anatomy:*



- Median lobe: bounded by the urethra anteriorly and the ejaculatory ducts posteriorly.
- 2 Lateral lobes: are on each side of the urethra.
- Posterior lobe: behind the plane of the ejaculatory ducts. lying below the level of the verumontanum.
- Anterior lobe: anterior to the urethra

❖ *Zonal Anatomy:*



<u>PERIPHERAL ZONE (PZ)</u>

- 70% of the glandular tissue.
- Apex, posterior and lateral prostatic tissue.
- Surround the urethra distal to the verumontanum.

<u>CENTRAL ZONE (CZ)</u>

- 25 % of the glandular tissue.
- Base of the prostate.
- Surrounds the ejaculatory ducts proximal to verumontanum.

<u>TRANSITIONAL ZONE (TZ)</u>

- 5 % of the glandular tissue.
- Surround the urethera proximal to verumontanum.

<u>Anterior Fibromascular stroma</u>

- contains no glandular tissue

❖ **Central gland = Central + Transition zones.**

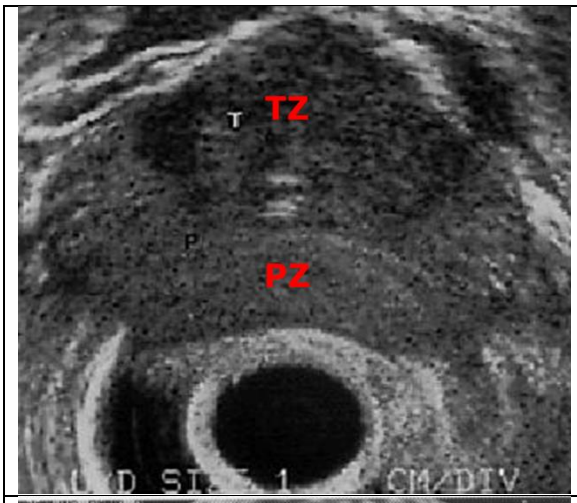
❖ **Peripheral gland = includes only peripheral zone.**

❖ ***<u>Periprostatic Neurovascular Bundles:</u>***

- course posterolateral to the prostate bilaterally.
- at 5- and 7-o'clock positions

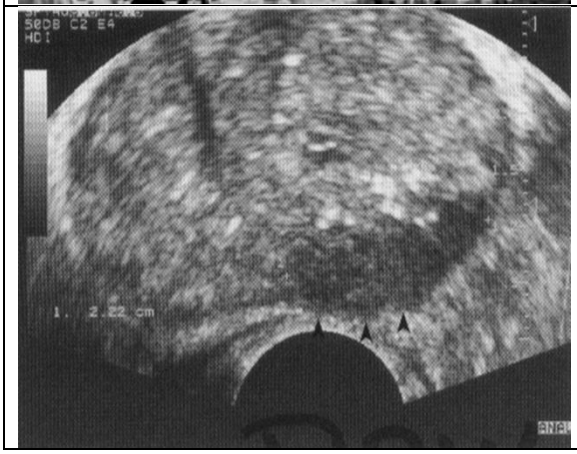
TRUS

- The entire gland is scanned in the transverse plane from the base to the apex.
- Next, the gland is viewed in the longitudinal plane.
- Then, the volume of prostate is calculated using the three dimensions.



Normal:

Transition zone (TZ) is hypoechoic
Peripheral zone (PZ) is Echogenic



Prostate cancer:

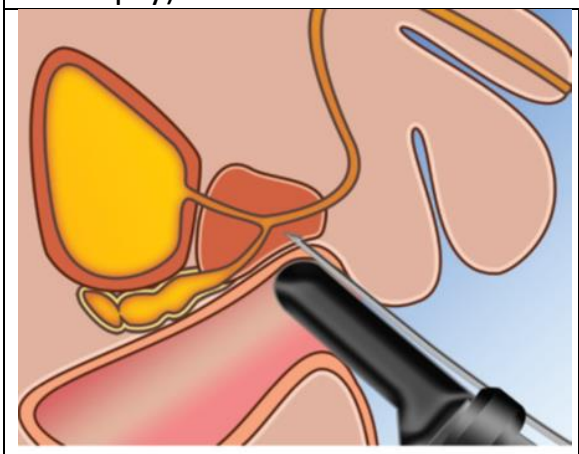
60-70% => Hypoechoic lesion
40% => Isoechoic lesion
1-5% => Hyperechoic lesion

❖ Role of TRUS in Intervention

- Guidance for biopsy.
- Placement of therapeutic radioactive iodine-125 seed implants.
- Cryotherapy.

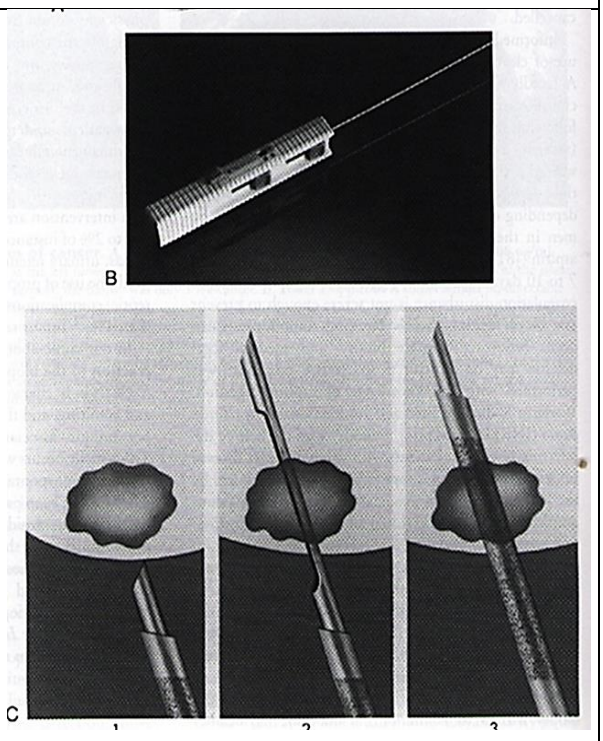
❖ TRUS - Guided Prostate Biopsy

- Abnormal DRE result
- Total PSA > 4.0 ng/mL
- Free PSA < 22%–25%
- PSA density > 0.15
- PSA velocity > 0.4–0.75 ng/mL/y
- Previous biopsy showed high-grade prostatic intraepithelial neoplasia or atypia (repeat biopsy is usually performed 3–12 months after the initial biopsy).



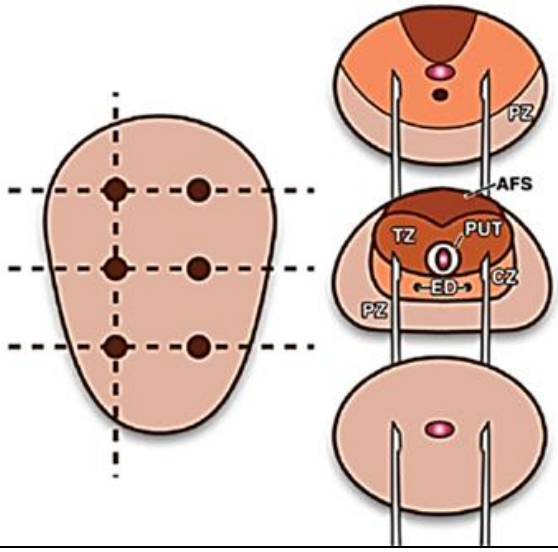
a.

b.



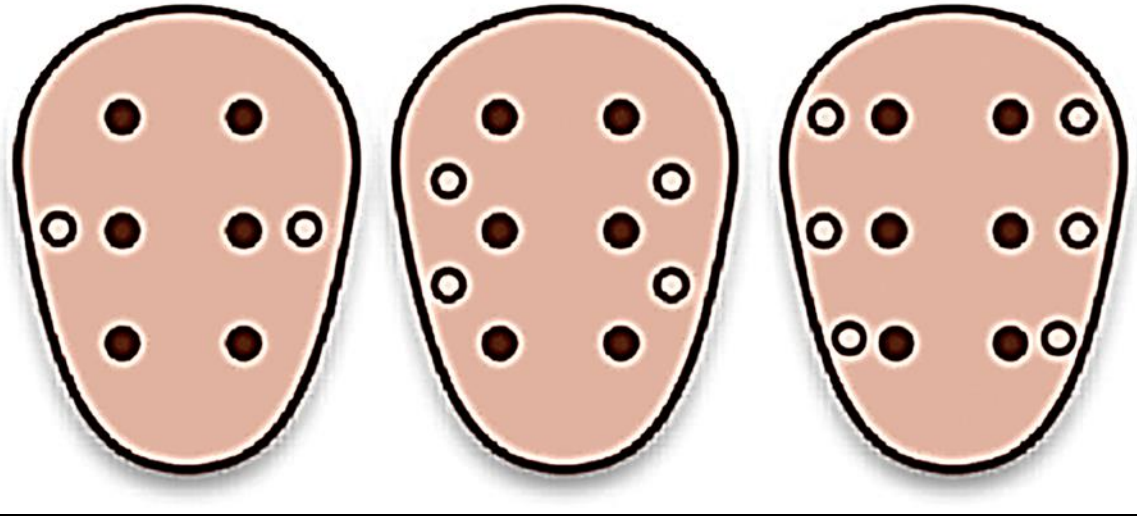
❖ Standard Sextant Biopsy

- Refers to the systematic biopsy of the right and left base, mid-gland, and apex of the prostate gland.
- Each core is then examined for the presence or absence of cancer



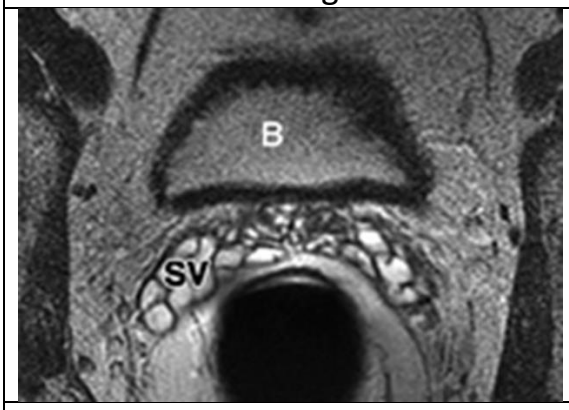
❖ Extended Systematic Biopsy

8 specimens	10 specimens	12 specimens

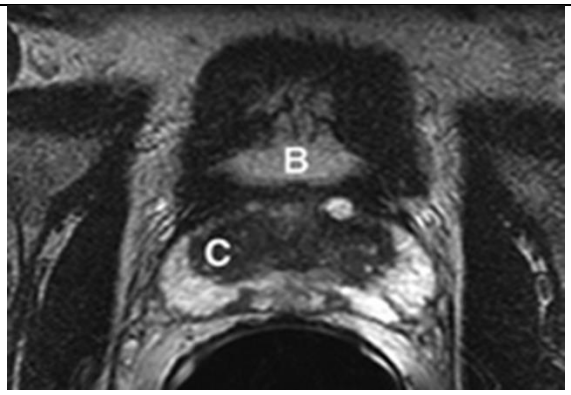


❖ MRI Zonal Anatomy on Axial T2 WI

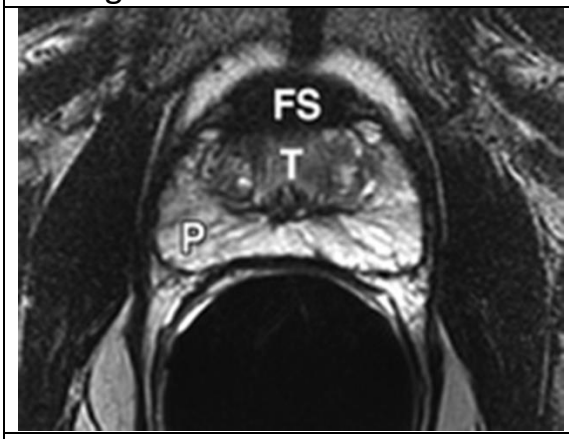
Axial T2 at level of Seminal Vesicles
Seminal vesicles : High T2 SI



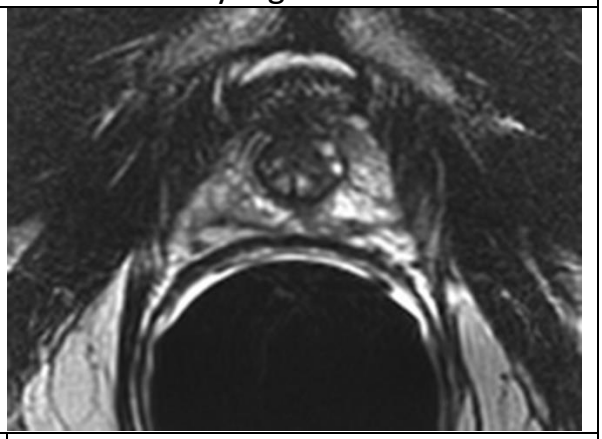
Axial T2 at level of Base of Prostate
CZ: Low T2 SI



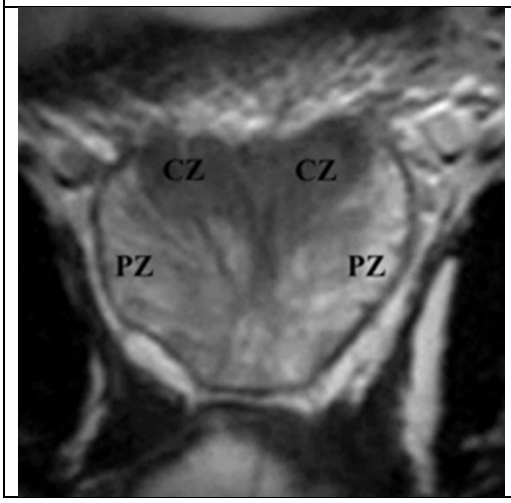
Axial T2 at level of Mid-gland:
TZ: Low SI
PZ: High SI



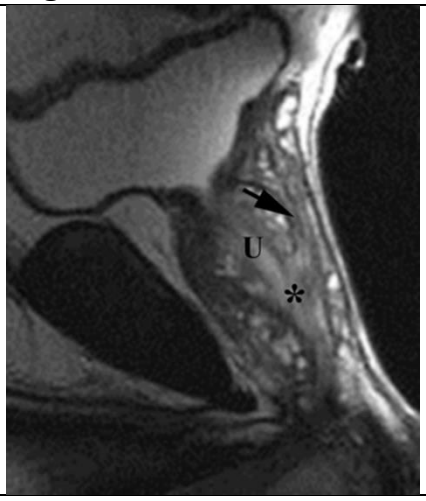
Axial T2 at level of Apex of gland
Urethra: Low SI
Surrounded by high SI PZ



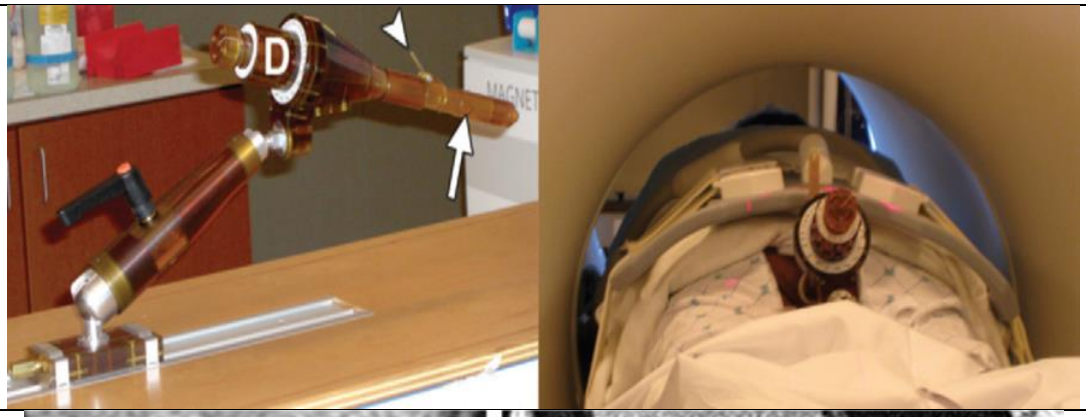
Coronal T2

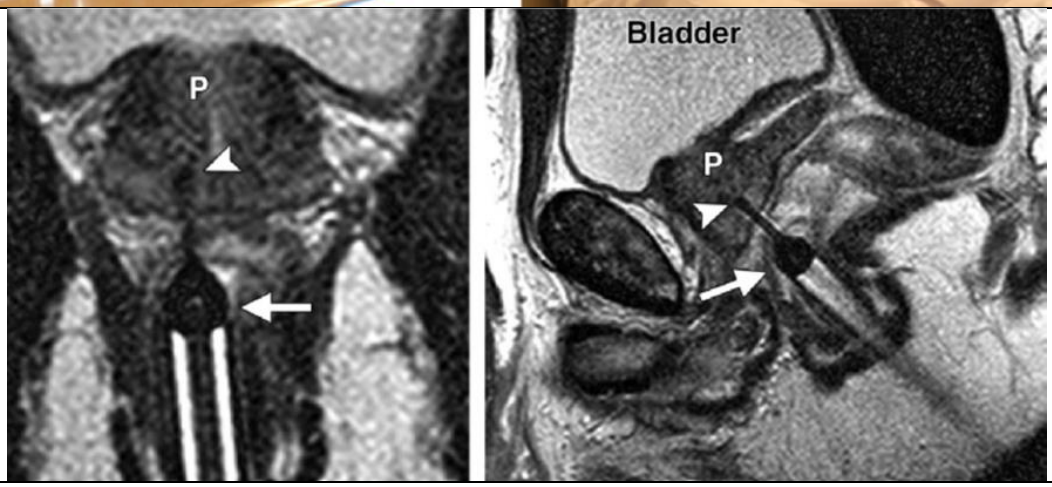


Sagittal T2



MR Imaging–guided Prostate Biopsy





Prostate Cancer

- Carcinoma of the prostate is an important health problem.
- 2nd most common cause of cancer-related death in men (after lung Cancer).

Risk factors:

- Age > 45 y
- Black races
- First degree relative
- Diet (high in animal fat, low in vegetables)

Screening of prostate carcinoma

- DRE
- PSA
- TRUS Biopsy(with PSA above 2.5 to 4ng/ml)

Histopathology:

- 95% are Adenocarcinomas.
- Remainder are squamous cell, transitional cell, and rarely carcinosarcomas

Clinical Picture:

- Majority of patients are Asymptomatic at diagnosis.
- Outlet obstruction—hesitancy, intermittent voiding, diminished stream, incomplete emptying, post void leakage, palpable bladder on exam.
- Pain secondary to bone metastases

Location:

- 70% in peripheral zone
- 25% in transition zone
- 5% in central zone.

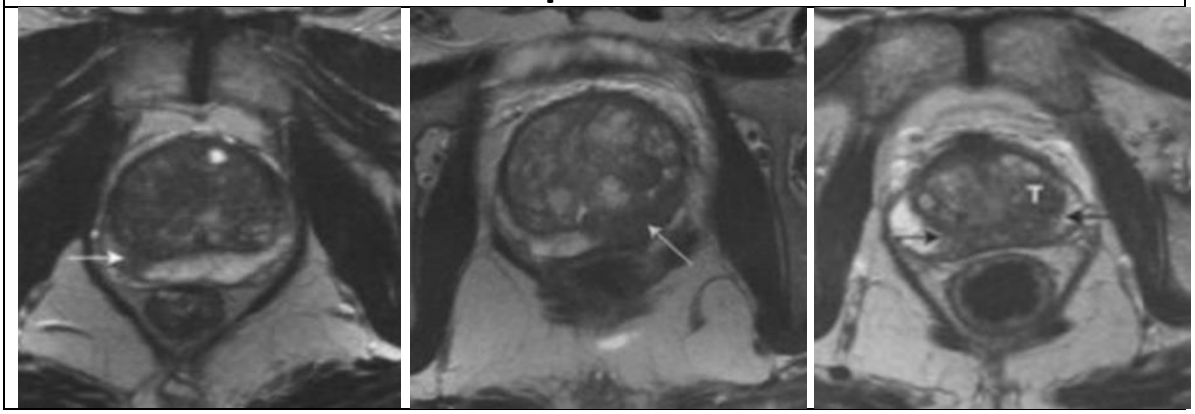
❖ TNM (2002) STAGING CLASSIFICATION

Tx Primary tumour cannot be assessed
T0 No evidence of primary tumour
Tis Carcinoma in situ
T1 Tumour identified on histology but
Not Apparent Clinically Or Radiologically
T2 Tumour CONFINED TO THE PROSTATE
- T2a Tumour involves less than one half of one lobe
- T2b Tumour involves more than one half of one lobe
- T2c Tumour involves both lobes

T3 Tumour extends beyond the prostatic pseudocapsule
- T3a Extra-capsular extension
- T3b Invading seminal vesicles

T4 Tumour FIXED or invading adjacent structures.

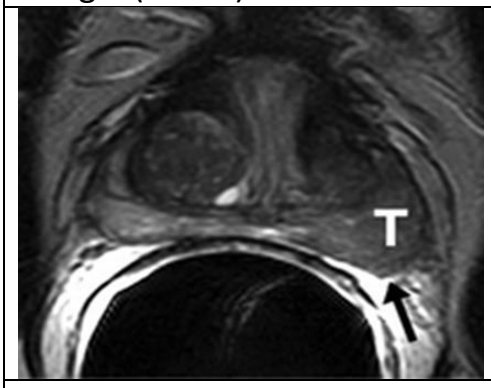
Stage T2a	Stage T2b	Stage T2c
Low signal tumor confined to < ½ of 1 lobe.	Low signal tumor involving > ½ of 1 lobe.	Low signal tumor involving both lobes and crossing midline.
No extra-capsular extension		



Stage T3a = Extra-capsular Extension

Extracapsular Extension Criteria on MR Images :

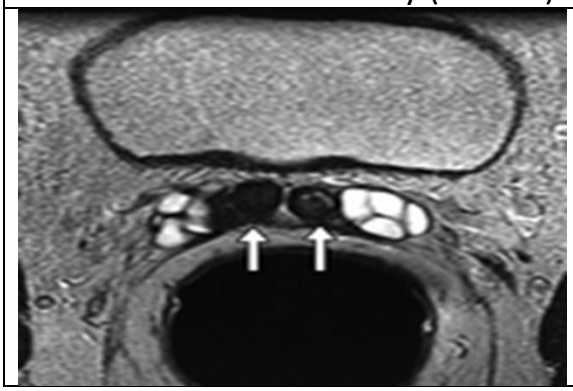
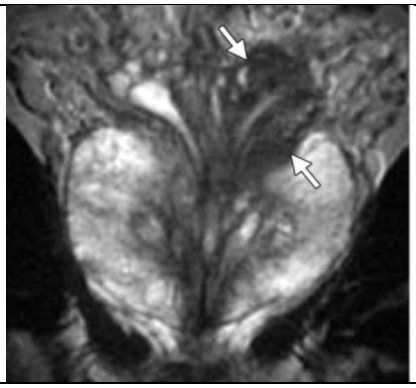
1) Neurovascular bundle asymmetry
2) Tumor envelopment of the neurovascular bundle
3) Angulated contour of the prostate gland.
4) Irregular, spiculated margin.
5) Obliteration of the rectoprostatic angle.
6) Contiguity with the pseudocapsule >12 mm.

Asymmetric bulge and spiculated margin (arrow)	Encasement of the left neurovascular bundle
	

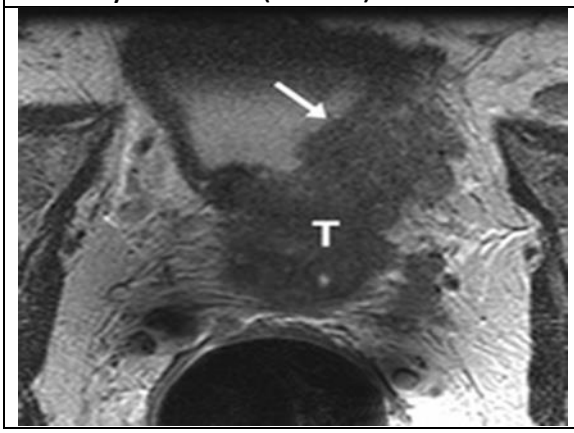
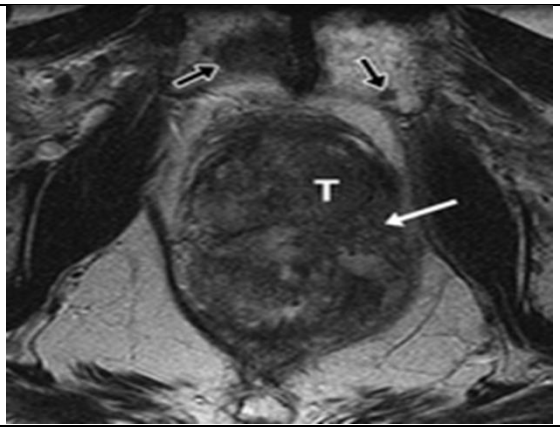
Stage T3b = Seminal Vesicle Invasion

Seminal Vesicle Invasion Criteria on MRI

1) Focal low SI of the seminal vesicle.
2) Enlargement with a low SI mass.
3) Direct tumor extension from the base of the prostate to the undersurface of the seminal vesicle.
4) Expanded low SI ejaculatory duct with low SI seminal vesicle.

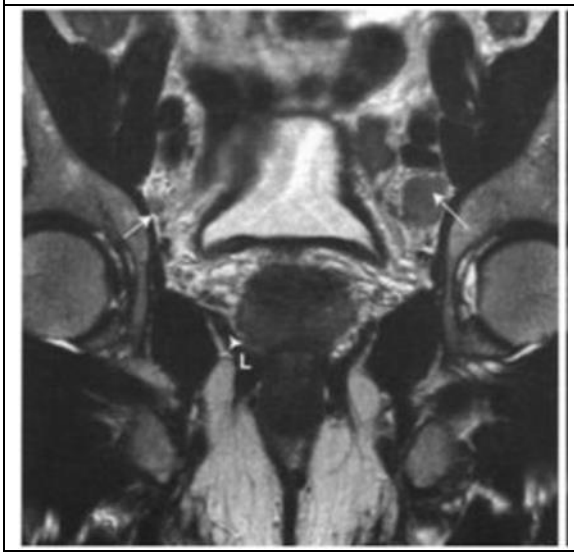
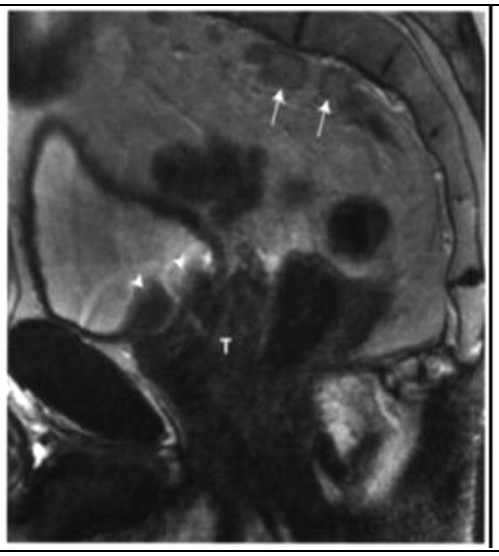
Focal areas of low SI within the seminal vesicles bilaterally (arrows).	Tumor extends from the left base into the left seminal vesicle
	

Stage T4 = Adjacent Organ Invasion

A large tumor (T) that invades the entire prostate gland and demonstrate gross extracapsular extension and direct invasion of the urinary bladder (arrow).	Diffuse tumor invasion of the prostate gland with direct tumor (T) extension to the anterior rectal wall (white arrow).
	

N- Staging

- The obturator LNs and iliac LNs are most commonly involved in prostate cancer.

Obturator LN	**Presacral LN**
	

M - Staging

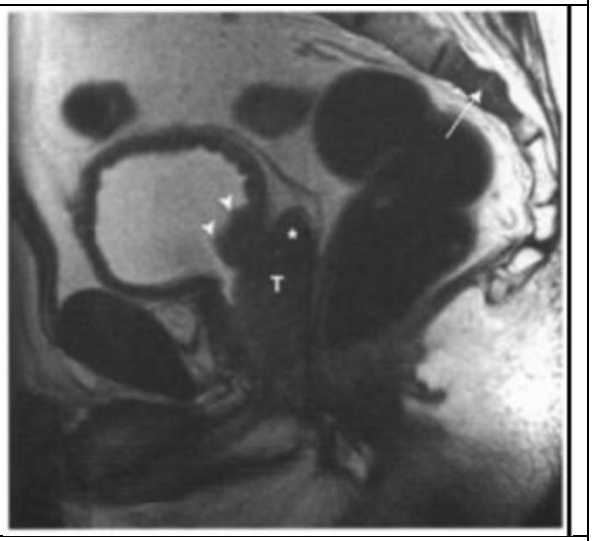
M0 No metastasis
M1a Non regional LNs metastasis
M1b Bone metastasis
M1c Extra-skeletal non nodal metastasis

Stage M1a

Multiple aortocaval and paraaortic retroperitoneal LNs are present (arrows).

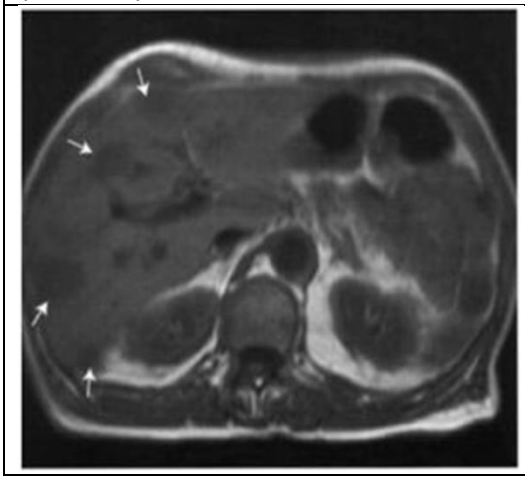
Stage M1b

A bone metastasis is present in the S3 segment (arrow).

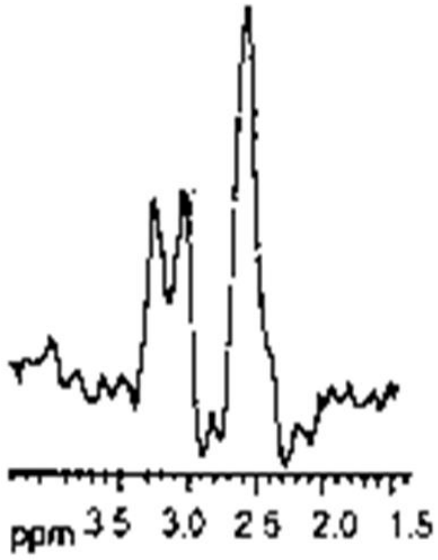
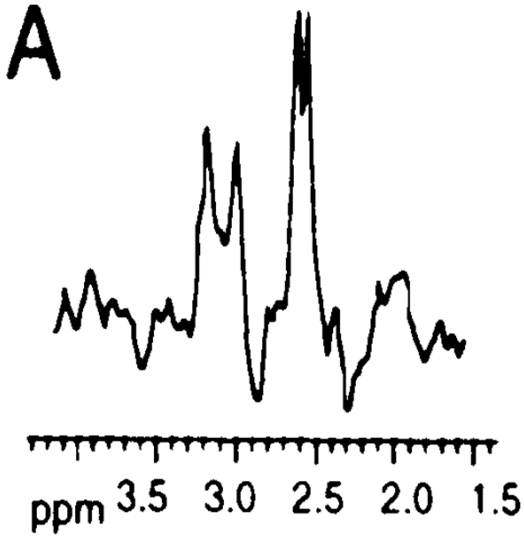
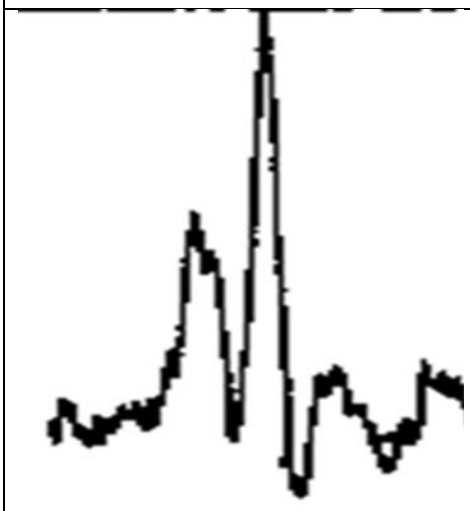
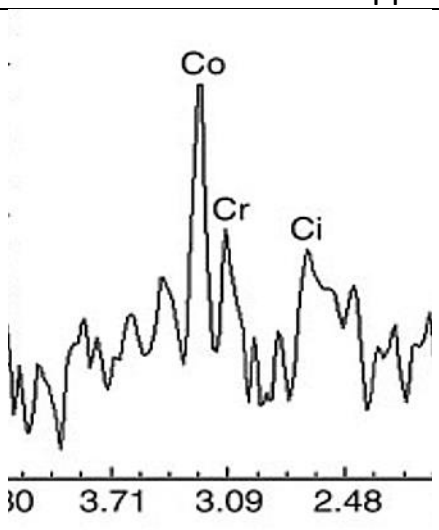


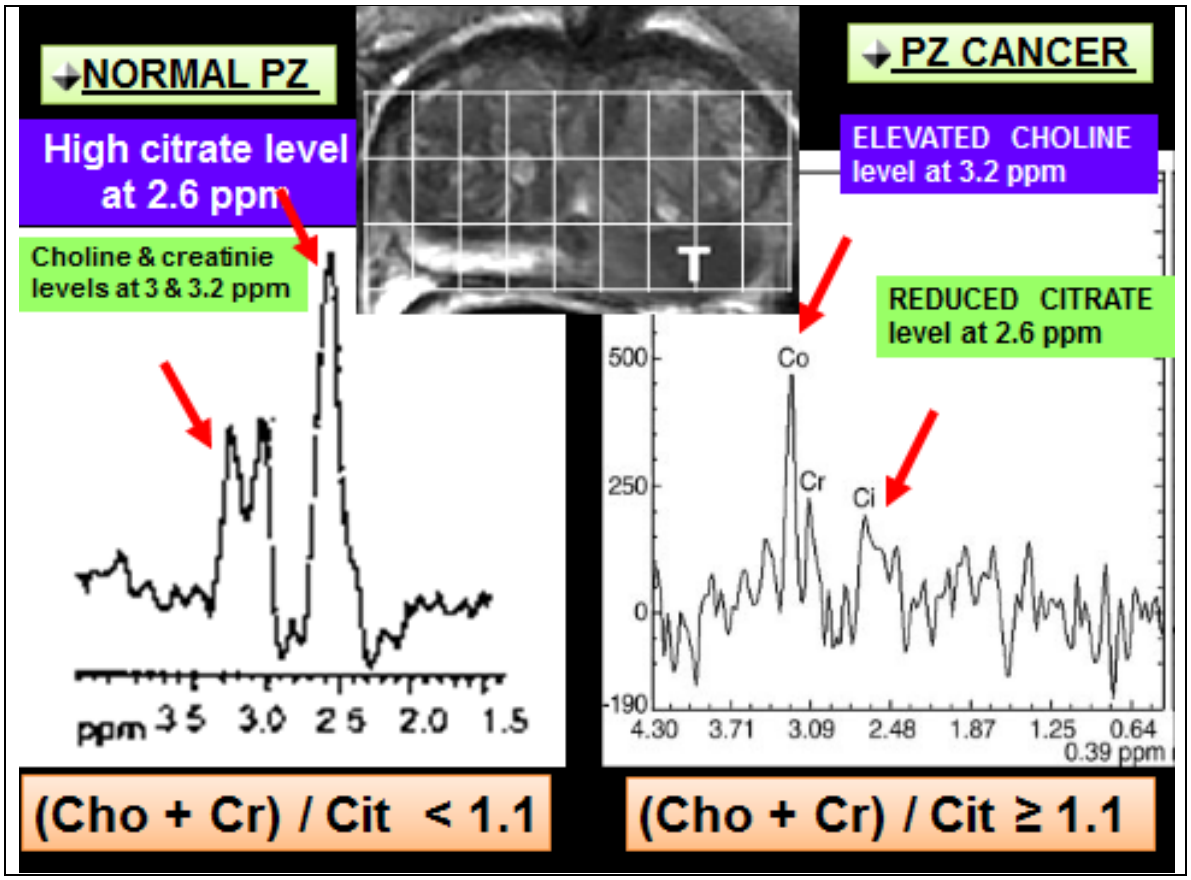
Stage M1c

Multiple hepatic metastases (arrows).

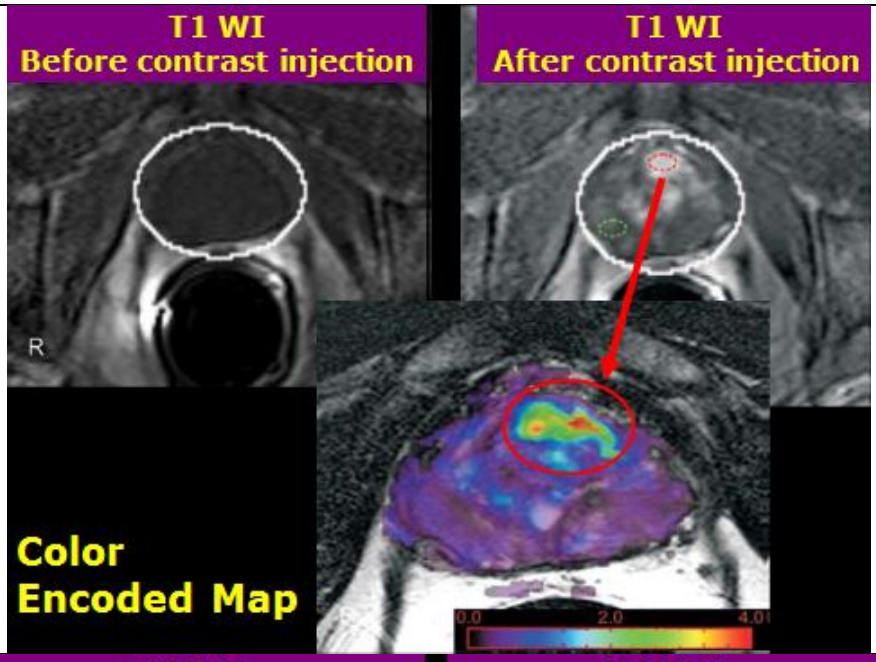


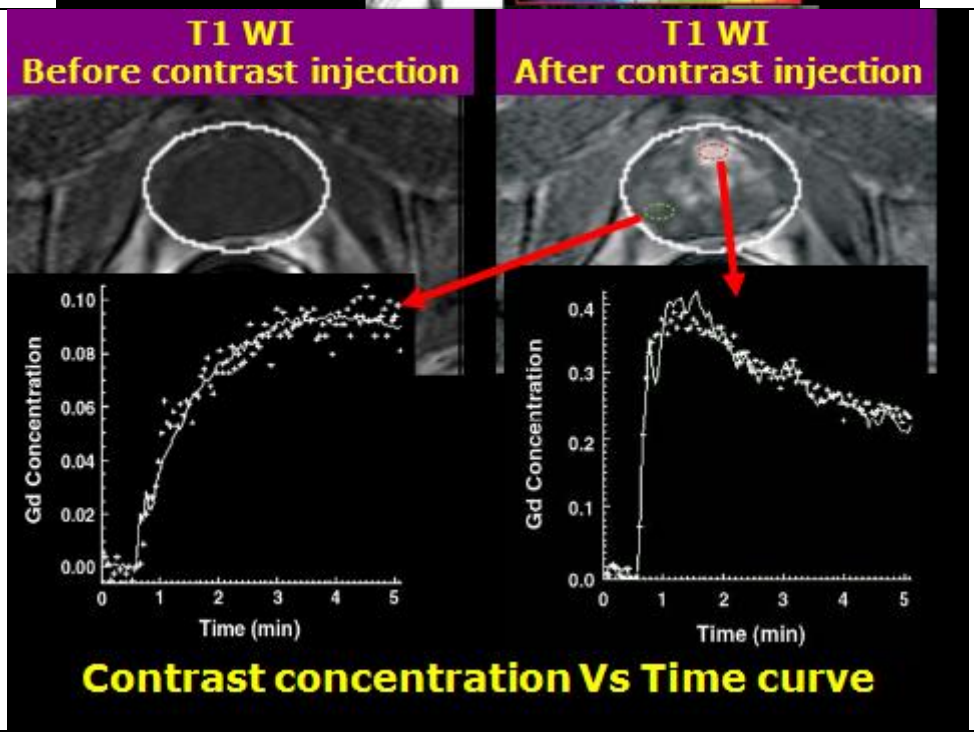
❖ MR SPECTROSCOPY

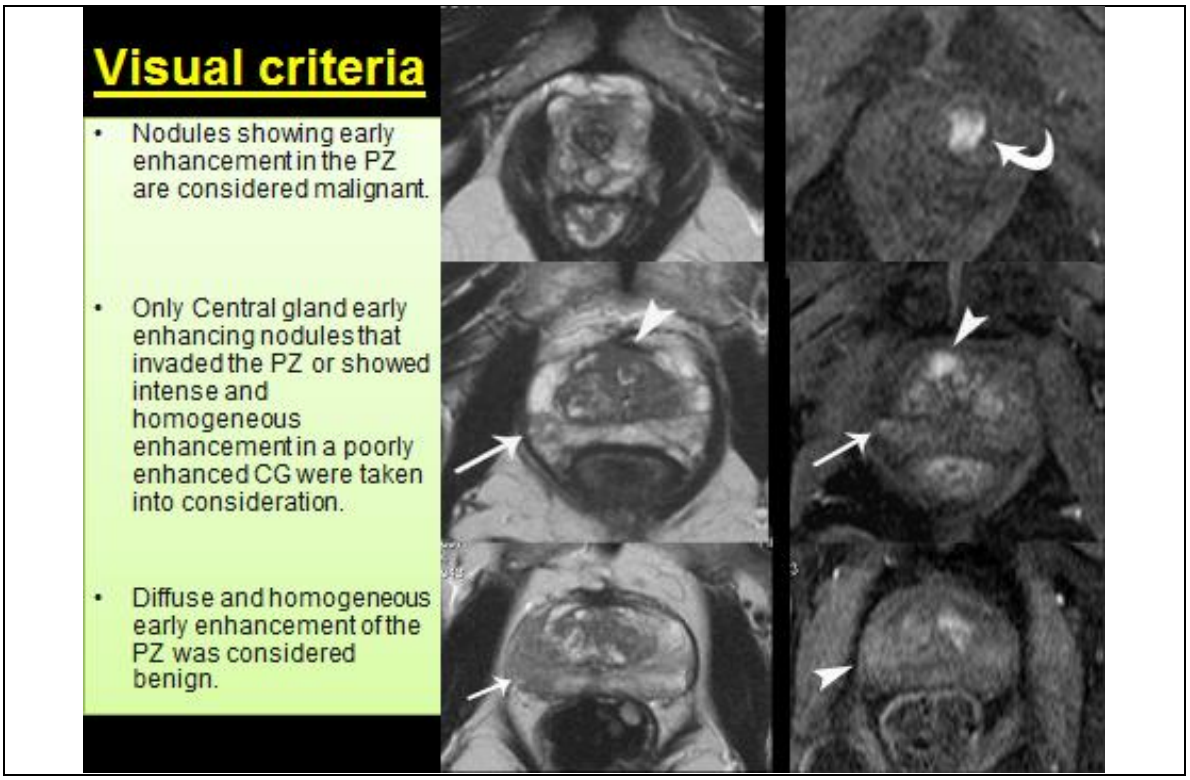
Normal peripheral zone	Normal Central Gland
High citrate resonance at 2.6 ppm	The citrate level is 60% lower in the central gland than PZ
60% lower choline & creatinie resonance at 3 & 3.2 ppm	No difference in choline level in various anatomic zones
	
BPH	
The level of citrate significant increase	Reduced citrate level at 2.6 ppm (Cho + Cr)/Cit ≥ 1.1
The level of choline mild increase	Elevated choline level at 3.2 ppm
	


NORMAL PZ
High citrate level at 2.6 ppm
Choline & creatinie levels at 3 & 3.2 ppm
ppm 3.5 3.0 2.5 2.0 1.5
(Cho + Cr) / Cit < 1.1
PZ CANCER
ELEVATED CHOLINE level at 3.2 ppm
REDUCED CITRATE level at 2.6 ppm
500
250
0
-190
Co
Cr
Ci
4.30 3.71 3.09 2.48 1.87 1.25 0.64
0.39 ppm
(Cho + Cr) / Cit ≥ 1.1

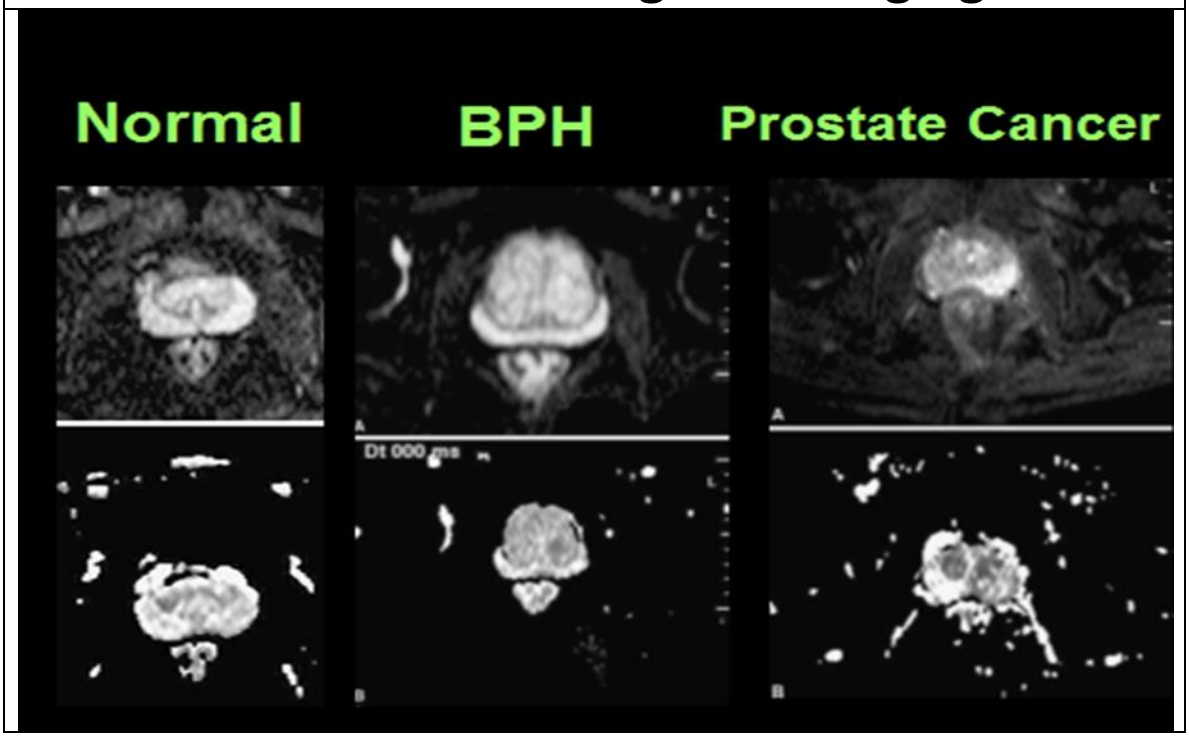
❖ MRI Dynamic Contrast Enhancement






Visual criteria
• Nodules showing early enhancement in the PZ are considered malignant.
• Only Central gland early enhancing nodules that invaded the PZ or showed intense and homogeneous enhancement in a poorly enhanced CG were taken into consideration.
• Diffuse and homogeneous early enhancement of the PZ was considered benign.

❖ MR Diffusion Weighted Imaging



PIRADS v2

Prostate Imaging and Reporting and Data System
PIRADS 1 – Very low (clinically significant cancer is highly unlikely to be present) **PIRADS 2 – Low (clinically significant cancer is unlikely to be present)** **PIRADS 3 – Intermediate (the presence of clinically significant cancer is equivocal)** **PIRADS 4 – High (clinically significant cancer is likely to be present)** **PIRADS 5 – Very high (clinically significant cancer is highly likely to be present)**

❖ Prostate Volume Assessment

- **Calculated using the formula for a conventional prolate ellipse formula (AP X TS X CC X 0.52).**

Sagittal T2	Axial T2

❖Mapping Lesion = Location on Sector map

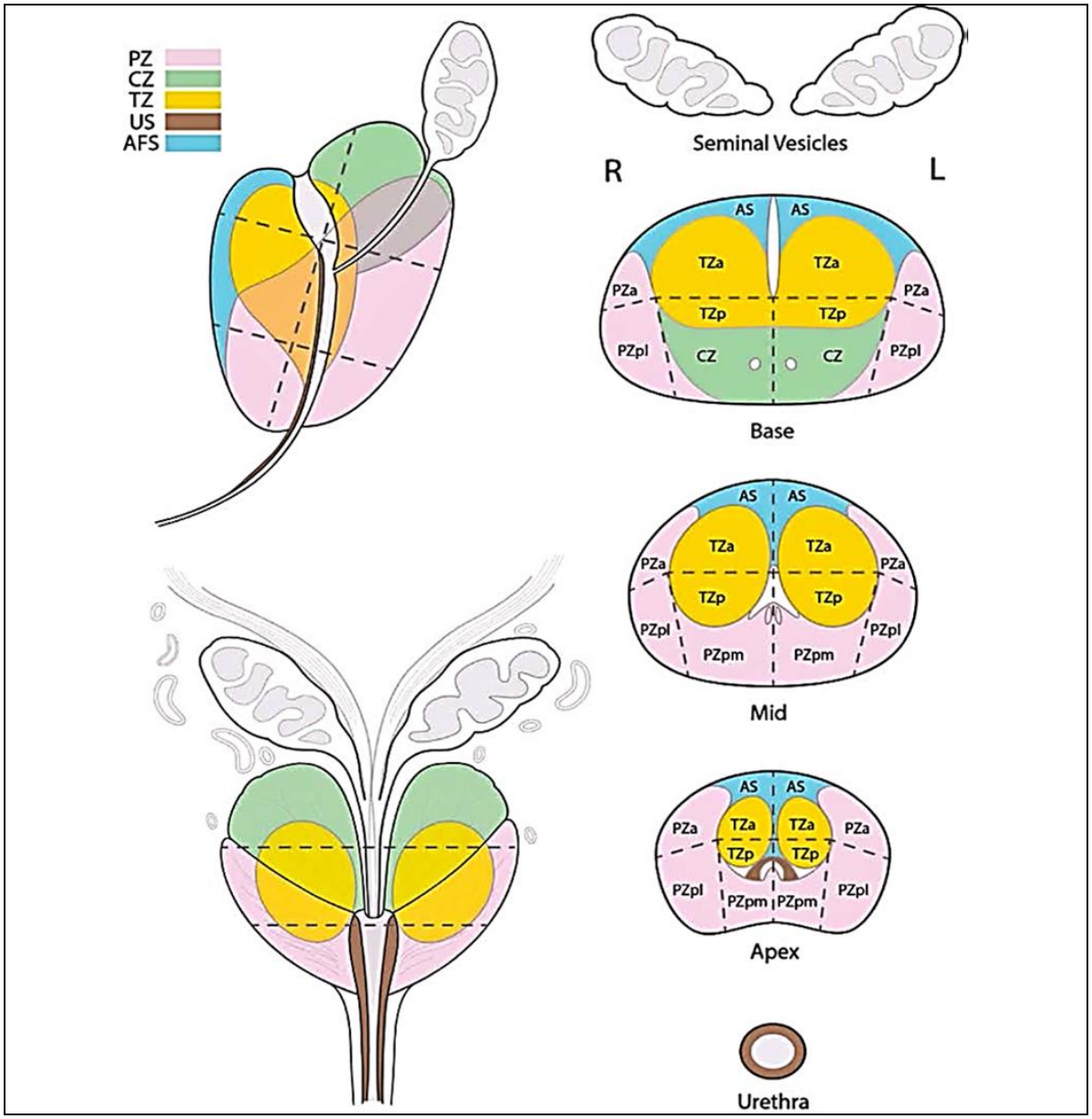
- The segmentation model used in PI-RADS™ v2 employs 39 sectors/regions:
  - 36 for the prostate
  - 2 for the seminal vesicles
  - 1 for the external urethral sphincter.

- The prostate is divided into 3 levels:
  - Base of prostate: upper 1/3 of the prostate
  - Mid prostate: middle 1/3 of the prostate that includes verumontanum in the mid prostatic urethra; midgland
  - Apex of prostate: lower 1/3 of the prostate

- The prostate is divided into right/left on axial sections by a vertical line drawn through the center (indicated by the prostatic urethra),
- The prostate is divided into anterior/posterior by a horizontal line through the middle of the gland

- The right and left peripheral zones (PZ) at prostate base, midgland, and apex are each subdivided into 3 sections: anterior (a), medial posterior (mp), and lateral posterior (lp).
- The right and left transition zones (TZ) at prostate base, midgland, and apex are each subdivided into 2 sections: anterior (a) and posterior (p).

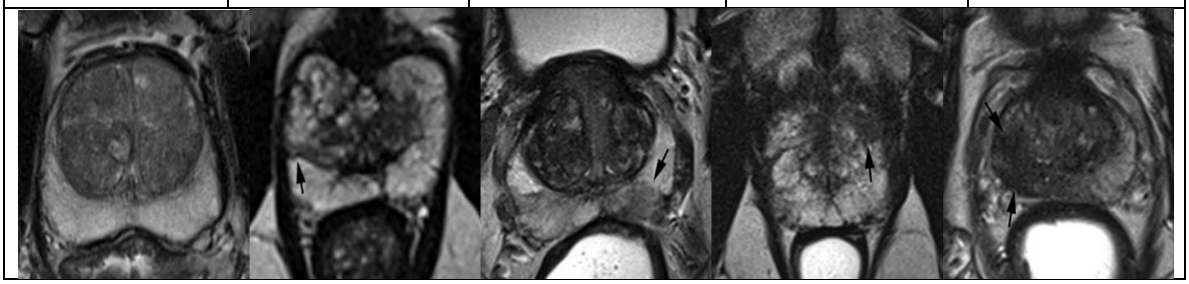
- The central zone (CZ) is included in the prostate base around the ejaculatory ducts.
- The anterior fibromuscular stroma (AS) is divided into right/left at the prostate base, midgland, and apex.
- The seminal vesicles (SV) are divided into right/left.
- The urethral sphincter (US) is marked in the prostate apex and along the membranous segment of the urethra.



PIRADS assessment of T2: PZ

Score	Peripheral Zone (PZ)
1	Uniform hyperintense signal intensity (normal)
2	Linear or wedge-shaped hypointensity or diffuse mild hypointensity, usually indistinct margin
3	Heterogeneous signal intensity or non-circumscribed, rounded, moderate hypointensity Includes others that do not qualify as 2, 4, or 5
4	Circumscribed, homogenous moderate hypointense focus/mass confined to prostate and <1.5 cm in greatest dimension
5	Same as 4 but ≥1.5cm in greatest dimension or definite extra prostatic extension/invasive behavior

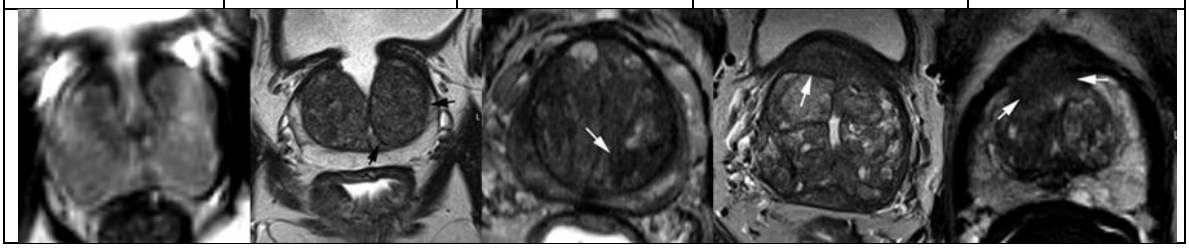
1	2	3	4	5



PIRADS assessment of T2: TZ

Score	Transition Zone (T)
1	Homogeneous intermediate signal intensity (normal)
2	Circumscribed hypointense or heterogeneous encapsulated nodule(s) (BPH)
3	Heterogeneous signal intensity with obscured margins Includes others that do not qualify as 2, 4, or 5
4	Lenticular or non-circumscribed, homogeneous, moderately hypointense, and <1.5 cm in greatest dimension
5	Same as 4, but ≥1.5cm in greatest dimension or definite extraprostatic extension/invasive behavior

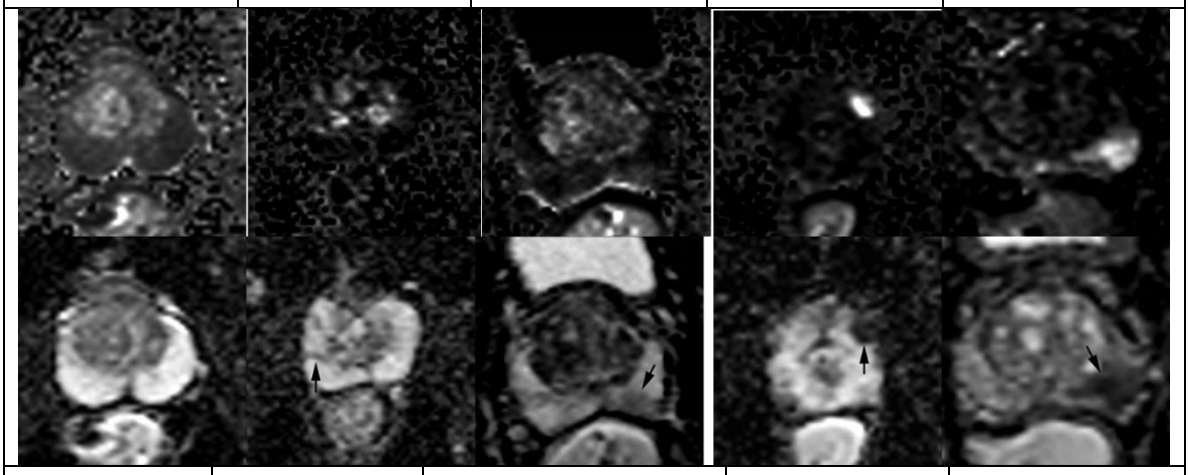
1	2	3	4	5



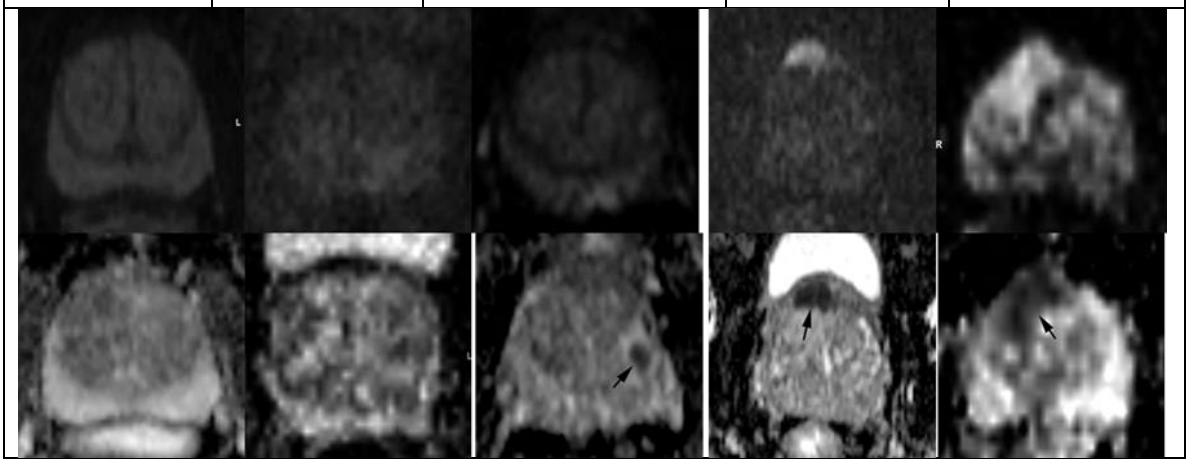
PIRADS assessment of DWI: PZ or TZ

Score	Peripheral Zone (PZ) or Transition Zone (TZ)
1	No abnormality (i.e., normal) on ADC and high b-value DWI
2	Indistinct hypointense on ADC
3	Focal mildly/moderately hypointense on ADC and isointense/mildly hyperintense on high b-value DWI.
4	Focal markedly hypontense on ADC and markedly hyperintense on high b-value DWI; <1.5cm in greatest dimension
5	Same as 4 but ≥1.5cm in greatest dimension or definite extraprostatic extension/invasive behavior

1	2	3	4	5



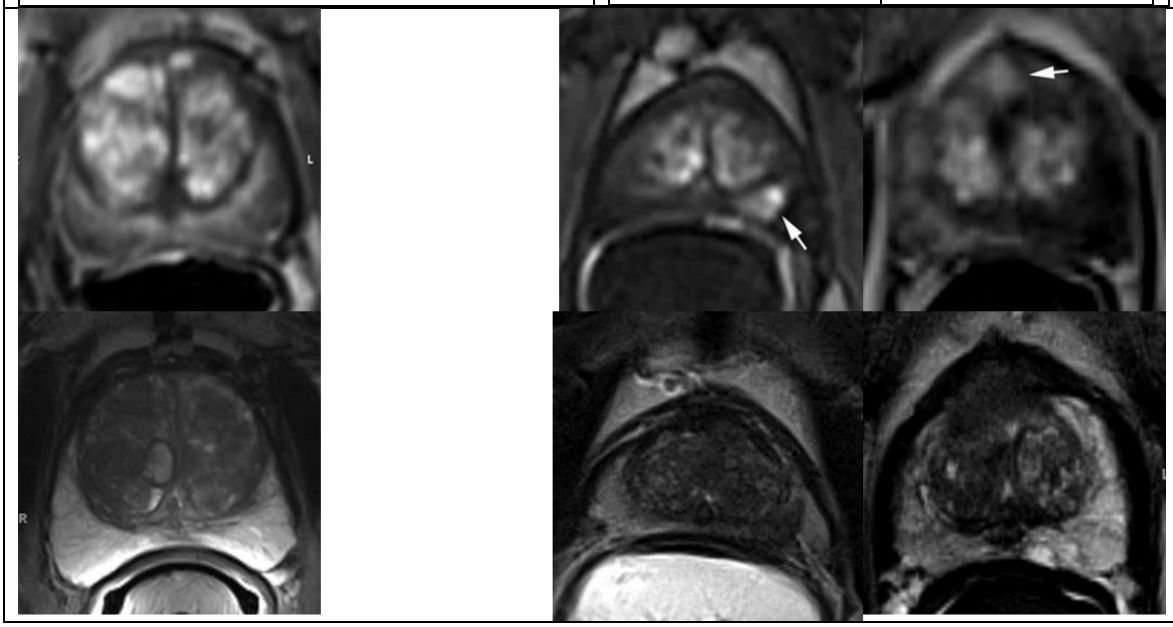
1	2	3	4	5

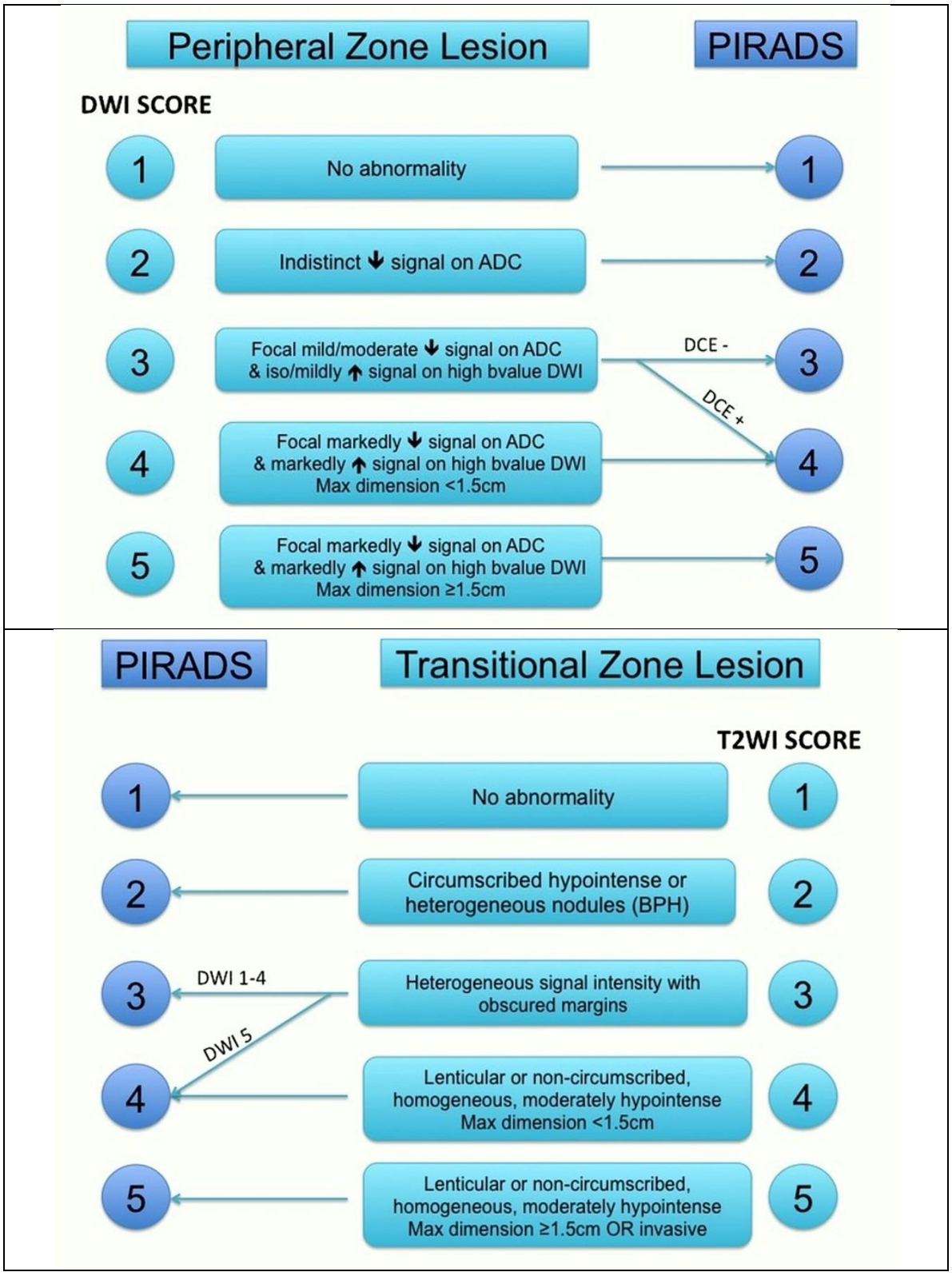


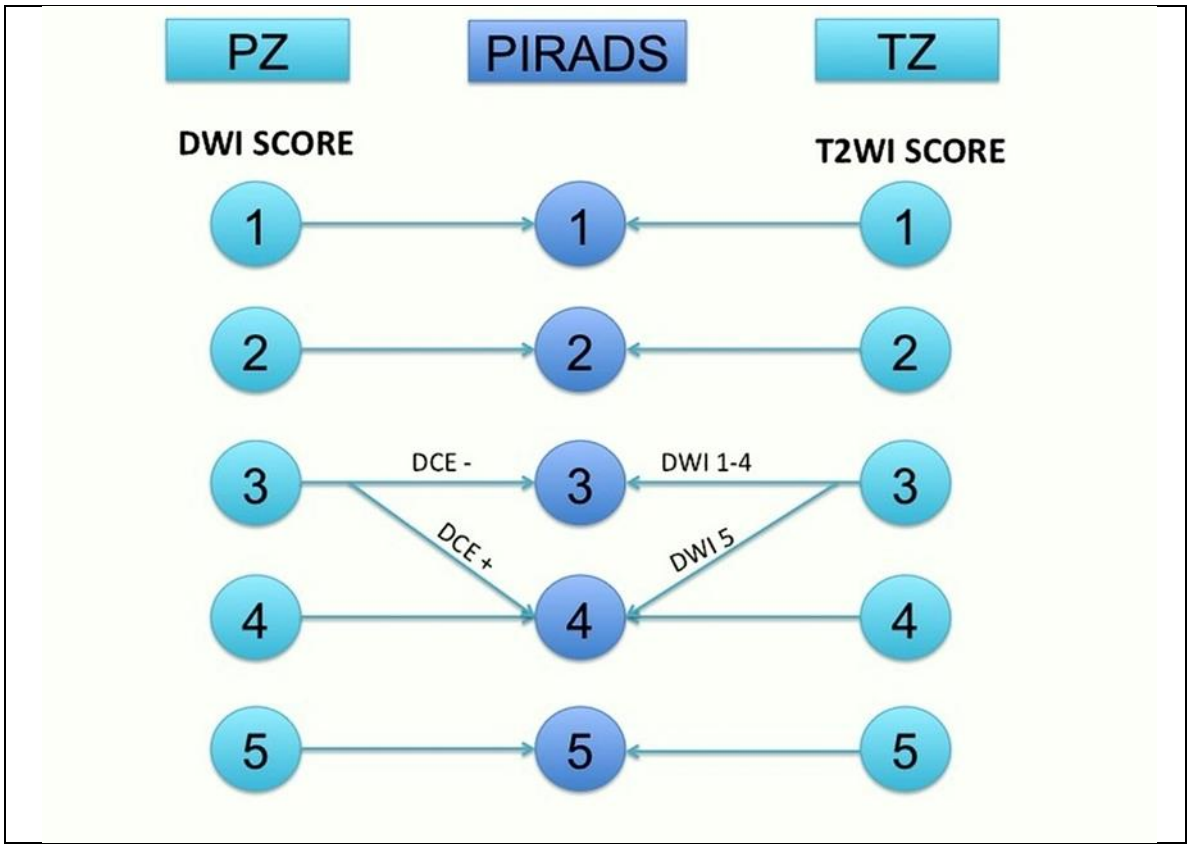
PIRADS assessment of DCE

Score	Peripheral Zone (PZ) or Transition Zone (TZ) for DCE
(-)	no early enhancement, or diffuse enhancement not corresponding to a focal finding on T2 and/or DWI or focal enhancement corresponding to a lesion demonstrating features of BPH on T2WI
(+)	focal, and; earlier than or contemporaneously with enhancement of adjacent normal prostatic tissues, and; corresponds to suspicious finding on T2W and/or DWI

Negative	Positive	
	PZ	TZ




Peripheral Zone Lesion
PIRADS
DWI SCORE
1
No abnormality
1
2
Indistinct ↓ signal on ADC
2
3
Focal mild/moderate ↓ signal on ADC
& iso/mildly ↑ signal on high bvalue DWI
DCE -
3
DCE +
4
Focal markedly ↓ signal on ADC
& markedly ↑ signal on high bvalue DWI
Max dimension <1.5cm
4
5
Focal markedly ↓ signal on ADC
& markedly ↑ signal on high bvalue DWI
Max dimension ≥1.5cm
5
PIRADS
Transitional Zone Lesion
T2WI SCORE
1
No abnormality
1
2
Circumscribed hypointense or
heterogeneous nodules (BPH)
2
3
DWI 1-4
Heterogeneous signal intensity with
obscured margins
3
DWI 5
4
Lenticular or non-circumscribed,
homogeneous, moderately hypointense
Max dimension <1.5cm
4
5
Lenticular or non-circumscribed,
homogeneous, moderately hypointense
Max dimension ≥1.5cm OR invasive
5


PZ
PIRADS
TZ
DWI SCORE
T2WI SCORE
1
1
1
2
2
2
3
DCE -
3
DWI 1-4
3
DCE +
DWI 5
4
4
4
5
5
5

Role of Multiparametric MRI of the prostate

- **Detection**
- **Staging**
- **Guide for Biopsy**
- **Follow up after therapy**

T1WI

- Haemorrhage,
- Nodal and skeletal metastases.(especially post contrast)
- Extraprostatic extension(EPE)

T2WI

- Slice thickness: 3mm, no gap.
- Locations should be the same as those used for DWI and DCE Zonal anatomy
- FOV: generally 12-20 cm to encompass the entire prostate gland and seminal vesicles
- Assess abnormalities within the gland
- Evaluate for seminal vesicle invasion
- EPE
- Nodal involvement.

DD of hypointense lesions in PZ on T2WI

- Prostatic carcinoma
- Prostatitis
- Hemorrhage
- Glandular atrophy
- Benign hyperplasia
- Biopsy scar
- After therapy(hormone, ablation)

DD: Hypointense on T2W, DWI and ADC

- Calcification
- Fibrosis
- Blood products
- Prior biopsy

Benign Findings

1) Benign Prostatic Hyperplasia (BPH)

- Benign prostatic hyperplasia (BPH) develops in response to testosterone, after it is converted to di-hydrotestosterone.
- BPH arises in the TZ, although exophytic and extruded BPH nodules can be found in the PZ.
- BPH consists of a mixture of stromal and glandular hyperplasia and may appear as band-like areas and/or encapsulated round nodules with circumscribed margins.
- Predominantly glandular BPH nodules and cystic atrophy => moderate-marked T2 hyperintensity and are distinguished from malignant tumors by their signal and capsule.
- Predominantly stromal nodules => T2 hypointensity.
- Many BPH nodules demonstrate a mixture of signal intensities.
- BPH nodules may be highly vascular on DCE
- BPH nodules can demonstrate a range of signal intensities on DWI.

- Since BPH tissue produces prostate-specific antigen (PSA), accurate measurement of gland volume by MRI is an important metric to allow correlation with an individual's PSA level and to calculate the

PSA density (PSA/prostate volume).

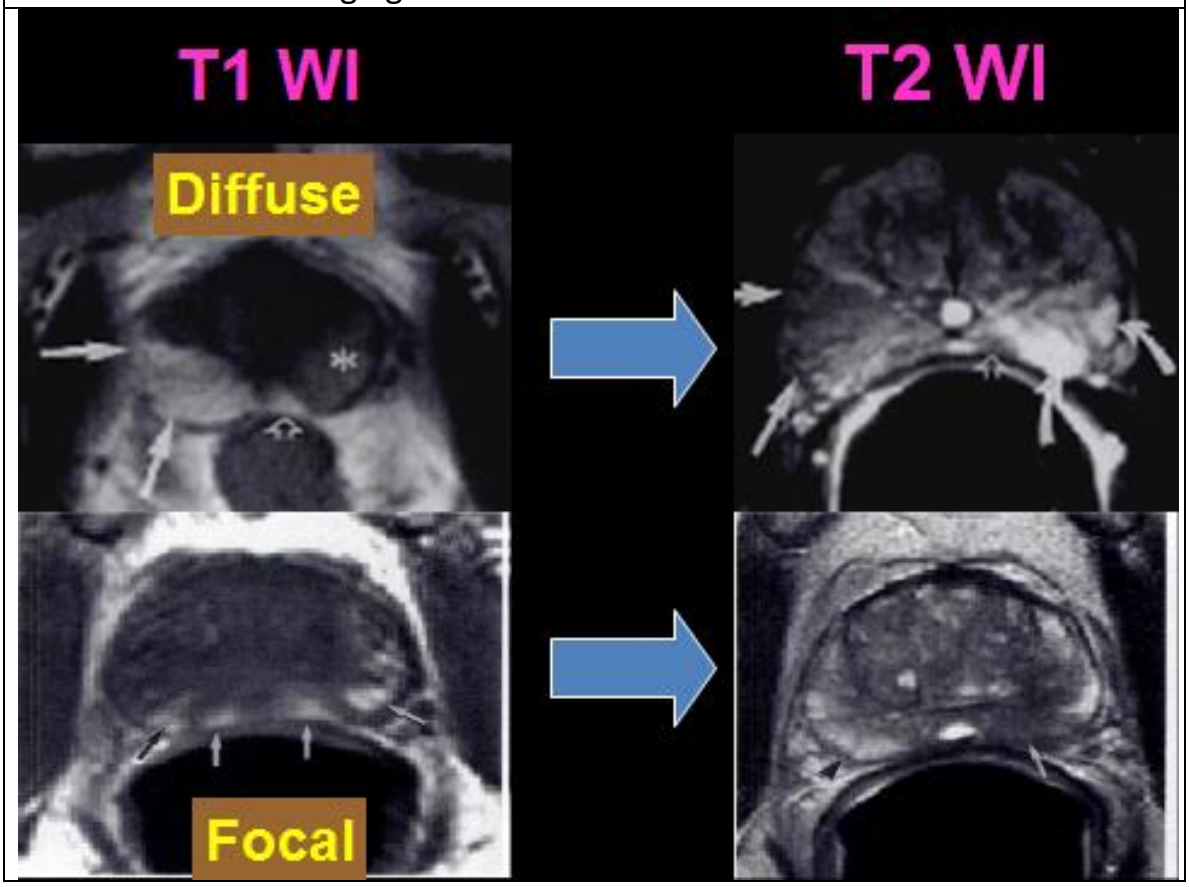
2) Calcifications

- Calcifications, if visible, appear as markedly hypointense foci on all pulse sequences.

3) Hemorrhage

- Hemorrhage in the PZ and/or seminal vesicles is common after biopsy.
- It appears as focal or diffuse hyperintense signal on T1W and iso-hypointense signal on T2W.
- Chronic blood products may appear hypointense on all MR sequences.

- Interval of at least 6 weeks or longer between biopsy and MRI should be considered for staging.



4) Prostatitis

- Prostatitis affects many men, although it is often sub-clinical.

Imaging findings:

- Decreased signal in the PZ on both T2W and ADC map.
- Increase perfusion, resulting in a "false positive" DCE result.
- However, the morphology is commonly band-like, wedge-shaped, or diffuse, rather than focal, round, oval, or irregular.
- The decrease in signal on the ADC map is generally not as great nor as focal as in cancer.

5) Atrophy

- Prostatic atrophy can occur as a normal part of aging or from chronic inflammation.

Imaging findings:

- Wedge-shaped areas of low signal on T2W and ADC map from loss of glandular tissue.
- The ADC is generally not as low as in cancer, and there is often contour retraction of the involved prostate.

6) Fibrosis

- Prostatic fibrosis can occur after inflammation.

Imaging findings:

- Wedge- or band-shaped areas of low signal on T2W.

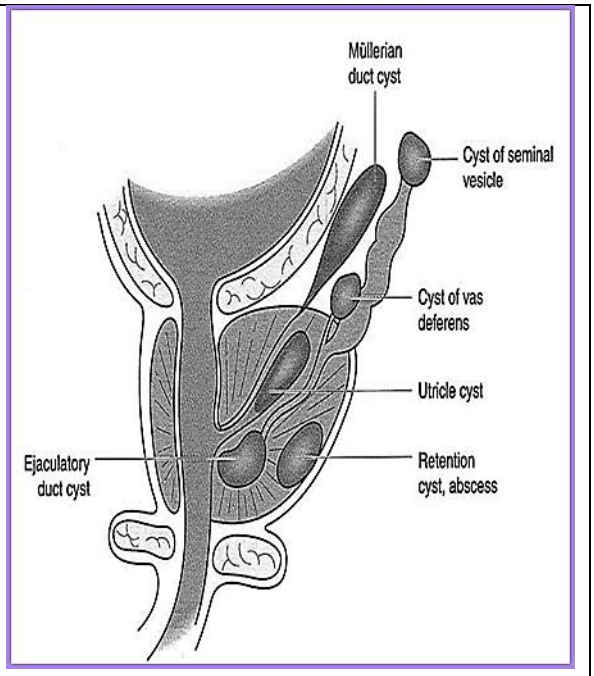
Prostatic Cystic Lesions

Midline Cysts

- **Utricle cyst**
- **Mullerian duct cyst**

Lateral cysts

- **Epidydymal cyst**
- **Seminal vesicles cyst**
- **Acquired cysts with BPH**



1) Prostatic Utricle Cyst

- Cystic enlargement of prostatic utricle is a vestigial remnant of mullerian duct

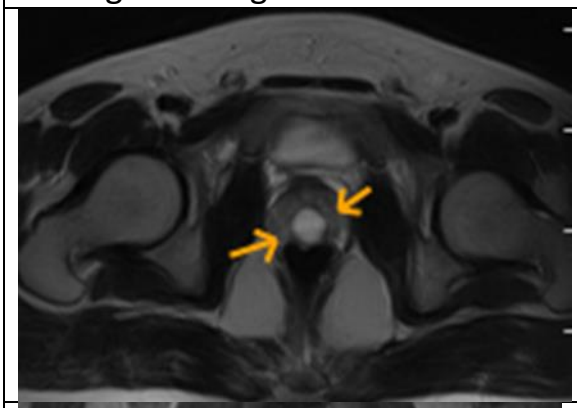
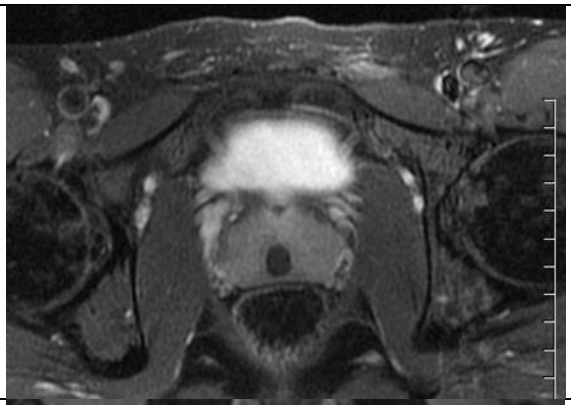
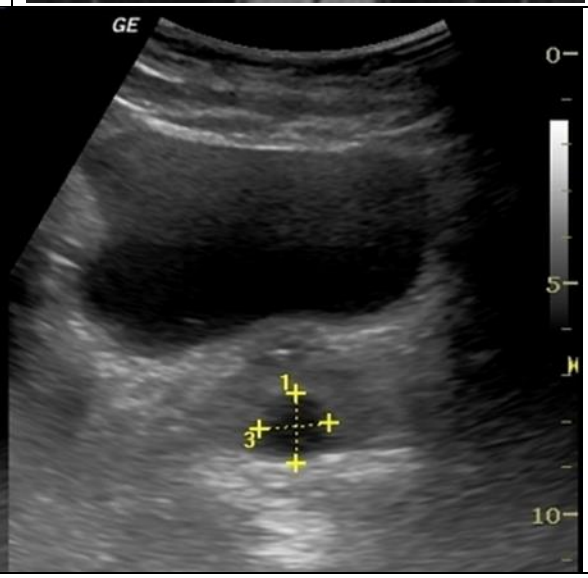
- Age: 1st and 2nd decades of life

Imaging findings:

- Within the prostate
- At the level of the verumontanum
- Midline.
- variable in size but are usually smaller (commonly <10 mm)
- do not extend either laterally
- do not extend above the prostate
- US: Anechoic
- MRI: Fluid signal
- T1: Low signal
- T2: High signal
- +C: No enhancement

Associations with other urogenital anomalies:

- Hypospadias
- Undescended testis
- Renal abnormalities including dysplasia.

T2: High fluid signal	+C: no enhancement
	
	

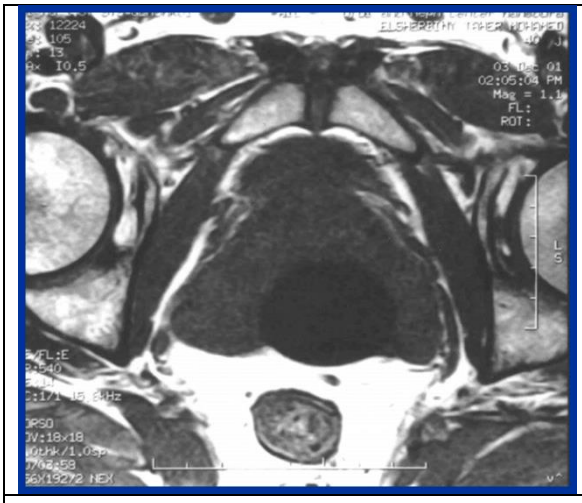
2) Mullerian duct cyst

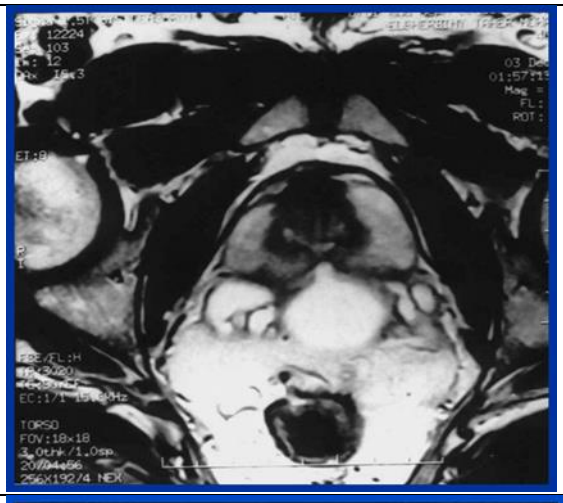
- is a cyst that arises from remnants of the Müllerian duct
- is one of the midline cystic masses in the male pelvis

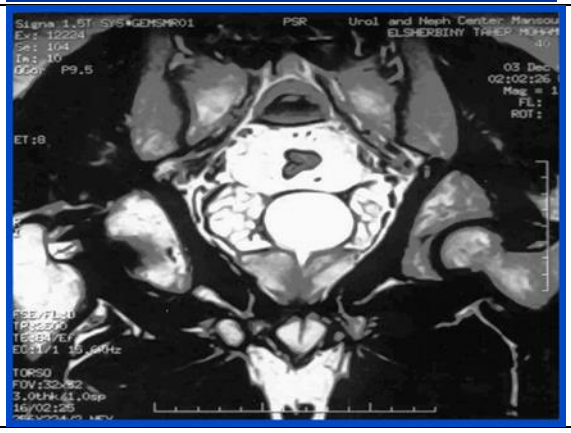
- Age: usually occur in the 3rd and 4th decades of life

Imaging findings:

- Arise anywhere along the path of Müllerian duct regression, from scrotum to utricle
- do not communicate with the urethra.
- Midline
- Extend above the prostate gland
- Larger in size







Male Genital System

B- Scrotum & Testis

Anatomy of the Scrotum

- **Testes:**
- Symmetric ovoid structures
- Size:
  - Birth: 1.5 x 1cm
  - Postpuberal: 5X3x2 cm
- Internal structure:
  - Mediastinum testis.
  - Testicular lobules.
  - Rete testis
- Tunica albuginea
- Tunica vaginals

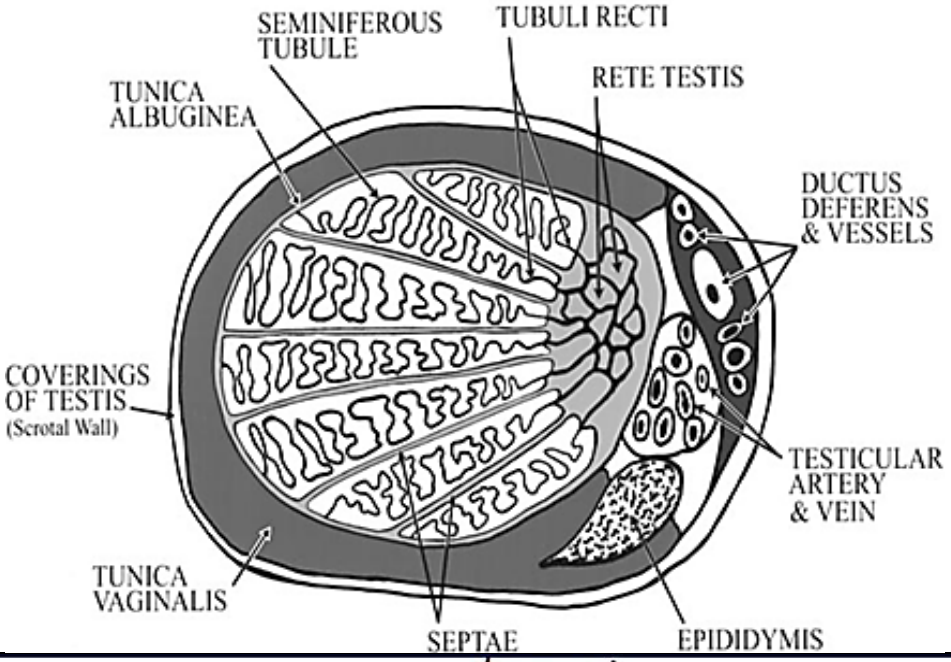
- **Appendix testis:**
  - 92% unilateral- 69% bilateral-
  - ovoid structure 5 mm in length, iso to testis and may be cystic

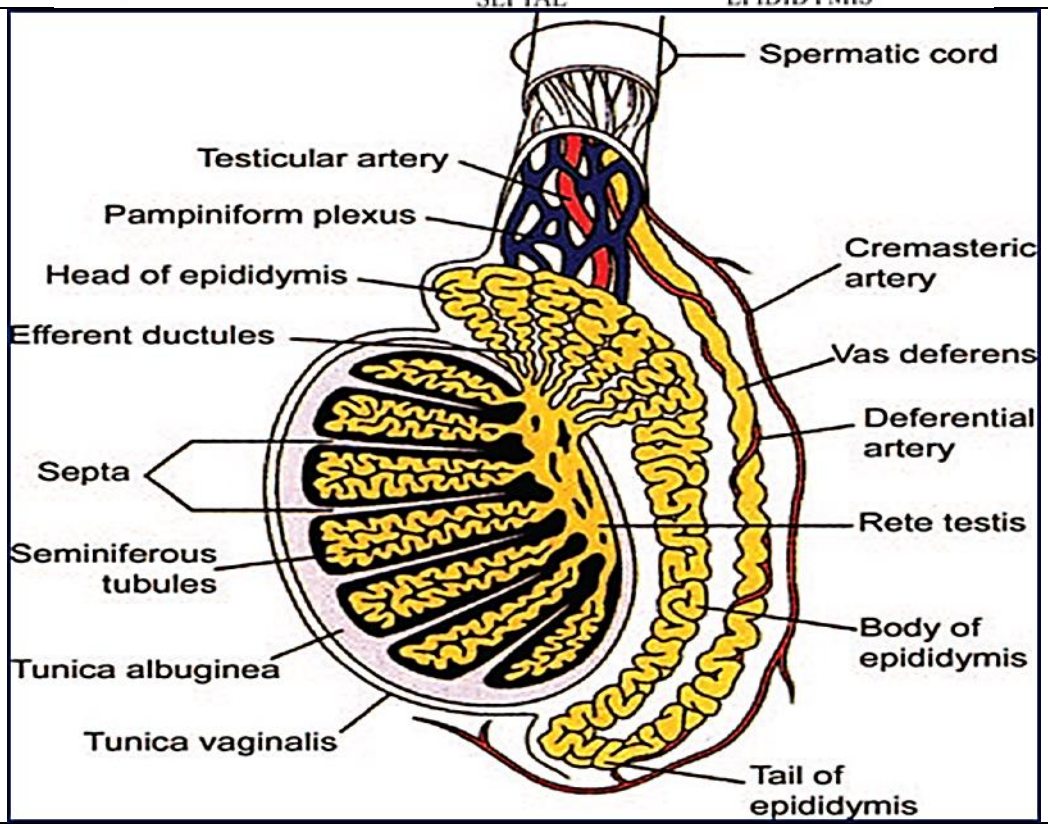
- **Epididymis:**
  - Head: Pyramidal structure 5-12 mm length, superior to testicle.
  - Body: 2-4 mm (normally could not be seen)
  - Tail : 2-5 mm at the inferior pole

- **Spermatic cord :**
  - Vas deferens
  - Testicular - cremastreic -deferential arteries
  - Pampiniform plexus of veins
  - Genitofemoral nerve- Lymphatic

- **Scrotal wall: Thickness 2-8 mm**
  - Skin- Superficial fascia.
  - Dartos muscle
  - External spermatic fascia.
  - Cremastric fascia.
  - Internal spermatic fascia

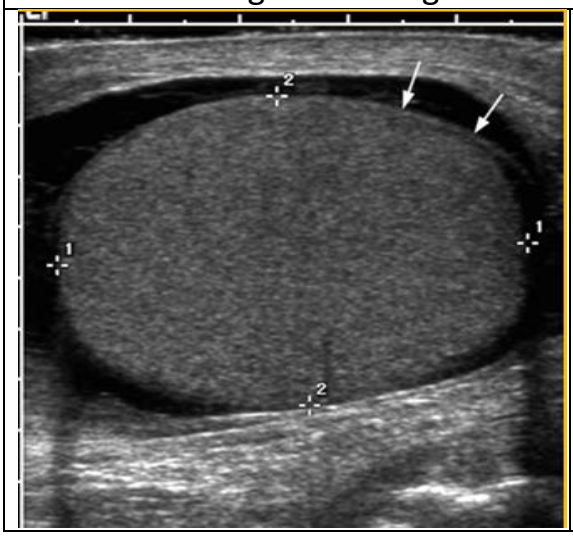
- **Arterial supply:**
  - Testicular artery <= Aorta distal to the renal artery.
- **Venous drainage:**
  - Pampiniform plexus => Testicular vein => IVC or left renal vein

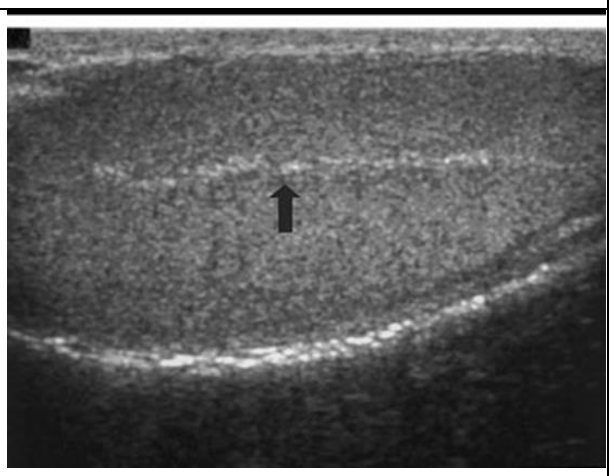

SEMINIFEROUS TUBULE
TUBULI RECTI
RETE TESTIS
TUNICA ALBUGINEA
DUCTUS DEFERENS & VESSELS
COVERINGS OF TESTIS (Scrotal Wall)
TESTICULAR ARTERY & VEIN
TUNICA VAGINALIS
SEPTAE
EPIDIDYMIS


Spermatic cord
Testicular artery
Pampiniform plexus
Head of epididymis
Efferent ductules
Septa
Seminiferous tubules
Tunica albuginea
Tunica vaginalis
Cremasteric artery
Vas deferens
Deferential artery
Rete testis
Body of epididymis
Tail of epididymis

❖ US Anatomy:

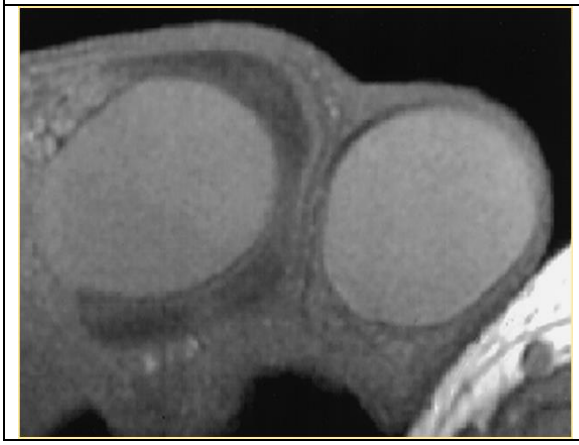
- Testis: Homogeneous medium echo.
- Mediastinum testis: Echogenic band in craniocaudal direction
- Tunica albuginea: Echogenic line around testis





❖ MRI Anatomy

T1	T2
• Testicular parenchyma: uniform intermediate signal intensity.	• Hyper intense testicular parenchyma • Hypo intense tunica albuginea • Mediastinum testis (arrows).



Testicular Tumors

- **Germ cell tumor: 95% of malignant testicular Tumors**
  - **Seminoma**
  - **Non-Seminoma:**
    - **Embryonal carcinoma**
    - **Yolk sac tumor**
    - **Choriocarcinoma**
    - **Teratoma**
- **Stromal tumor:**
  - **Leyding cell T- Sertoli cell T**
  - **Granulosa cell T – Fibroma- Thecoma**
- **Mesenchymal tumor:**
  - **Leiomyoma**
  - **Neurofibroma**
  - **Adenomatoid tumour**
  - **Hemangioma-Sarcoma**
- **Lymphoid and Hamatopiotic Tumors:**
  - **Lymphoma**
  - **Leukemia**
- **Metastasis [prostate- bronchus- m.melanoma-colon]**

❖ Seminoma

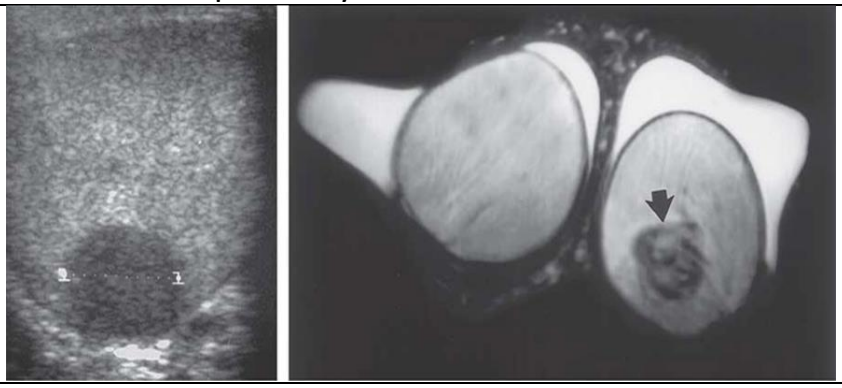
- It is the most common pure germ cell tumor.
- It accounts for 35%–50% of all germ cell tumors.
- Seminomas, in comparison with nonseminomatous tumors, occur in a somewhat older population, with an average patient age of 40.5 years.

US Findings:

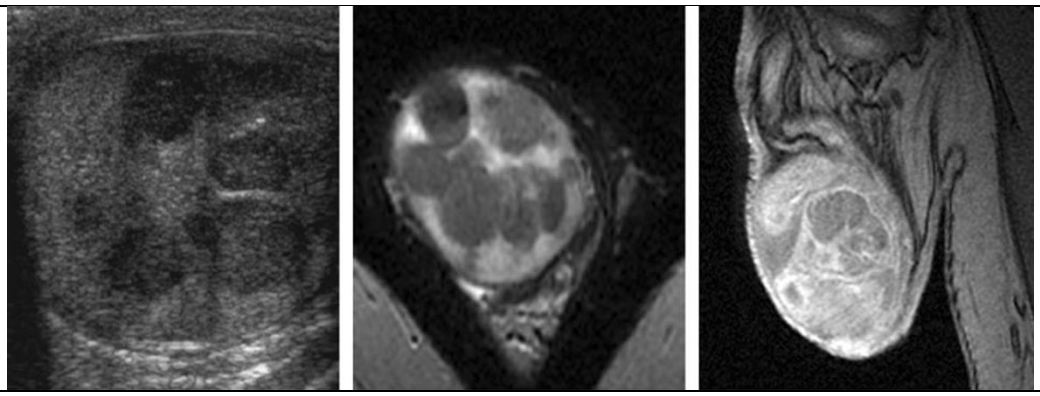
- Homogenous hypoechoic
- Smooth lobulated margin
- Whole testis involved in more than 50%
- Cystic component , calcifications in 10%
- Rarely extend beyond tunica.
- 25% lymphatic and hematogenous spread

MRI findings:

- T1: Isointense
- T2: Hypointense
- +C: Increased contrast enhancement of malignant tissue compared with normal contralateral parenchyma



Multifocal Seminoma



❖ Non- Seminomatous Tumors

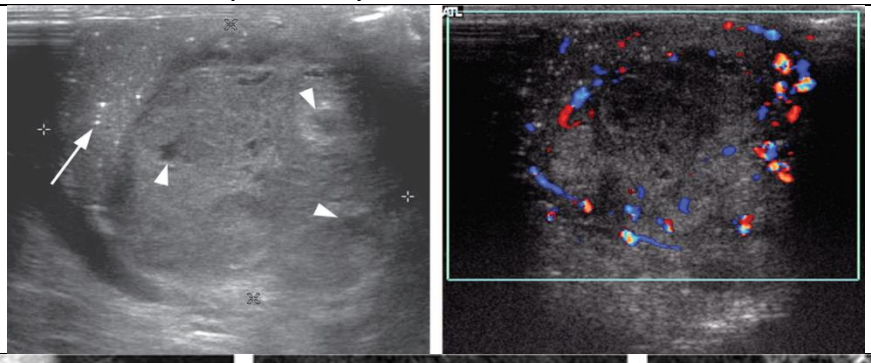
- Age: Men aged around 30s
- Elevated alpha fetoprotein level in Yolk sac T.

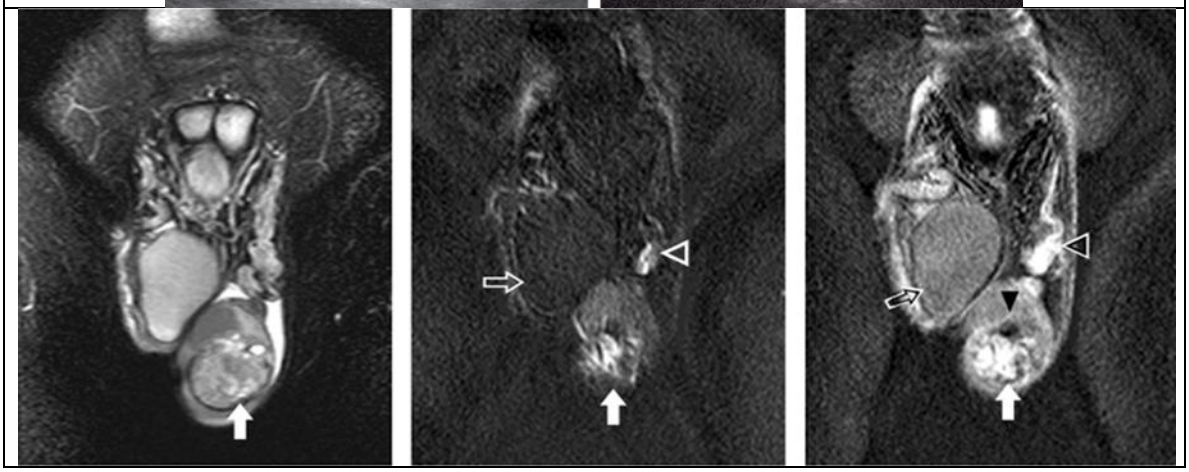
US:

- Inhomogeneous hypoechoic texture (70%)
- ill-defined margins
- Cystic component 60%
- Calcifications- Hemorrhage- Fibrosis
- 60% manifest as advanced disease

MRI findings:

- T1: Isointense
- T2: Hypointense
- +C: Increased contrast enhancement of malignant tissue compared with normal contralateral parenchyma





Extra – Testicular Tumors

Benign	Malignant
• Adenomatoid tumor • Fibroma • Lipoma • Hemangioma • Leiomyoma • Neurofiroma • Cholesterol dranuloma • Adrenal rest • Papillary cystadenoma	• Fibrosarcoma • Liposarcoma • Rhabosarcoma • Histoctyoma • Lypmhoma • Metastasis

1) Adenomatoid Tumor

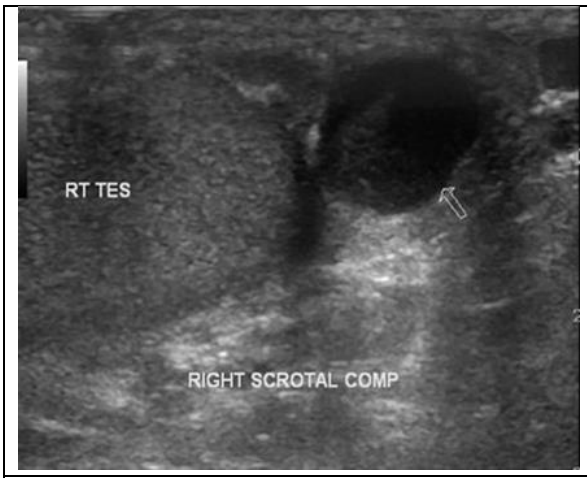
- Adenomatoid tumors are the most common tumors of the epididymis.
- It accounts for nearly one-third of all paratesticular neoplasms.

Location:

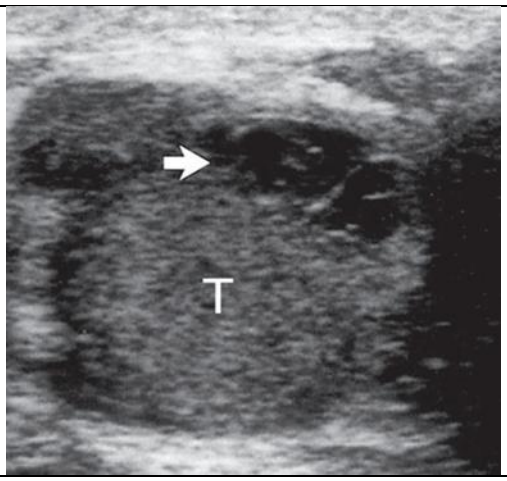
- Lower pole >>> upper pole of epididymis.
- It usually unilateral.
- It is more common on the left side

Imaging findings:

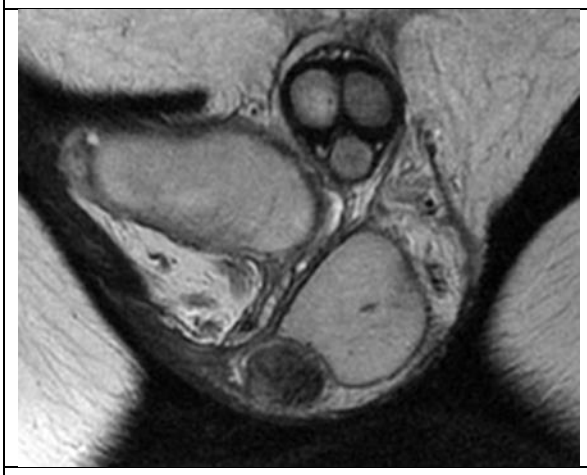
- US: well-defined solid extra testicular mass with variable echogenicity
- T2: low signal intensity relative to the testicular parenchyma
- C+: show enhancement



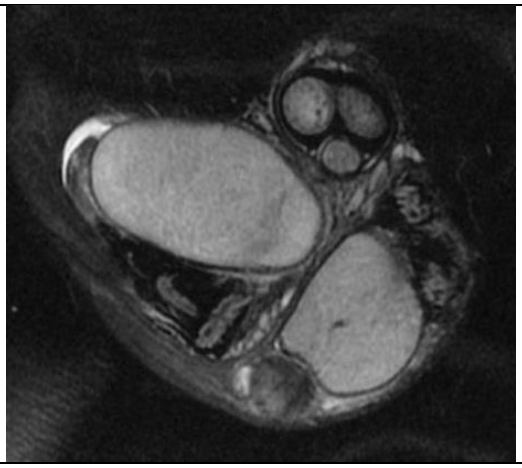
Coronal T2



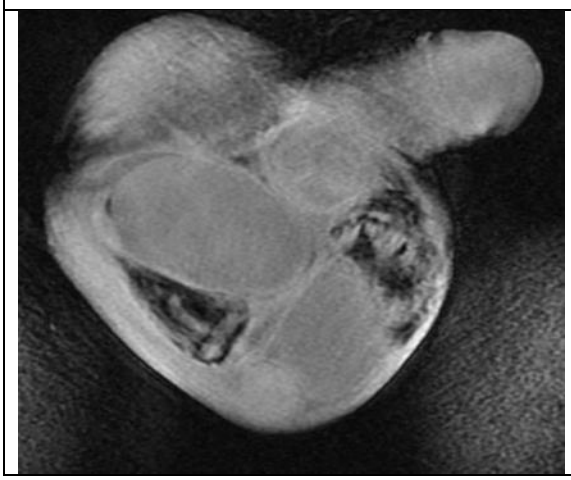
Coronal T2 FS

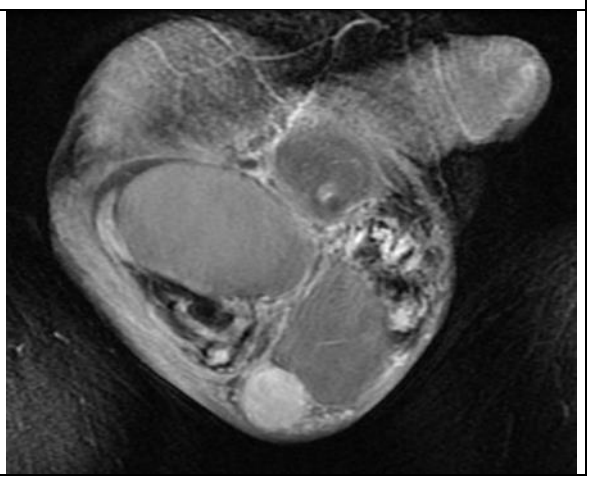


Coronal T1 FS



Coronal T1 FS +C



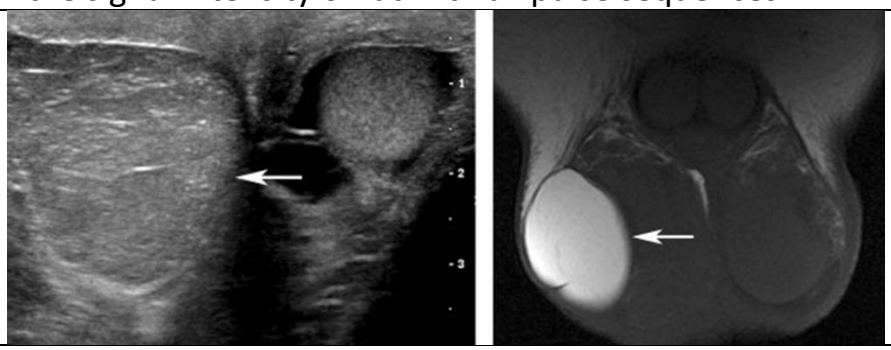


2) Spermatic Cord Lipoma

- Lipoma is the most common benign tumor of the spermatic cord and can occur at any age

Imaging findings:

- Paratesticular lesion.
- US: Large, well-defined, homogeneous, hyperechoic
- T1: high signal intensity.
- T1 FS: The lesion had low signal intensity
- Follow the signal intensity of fat with all pulse sequences.



3) Fibrous Pseudotumor

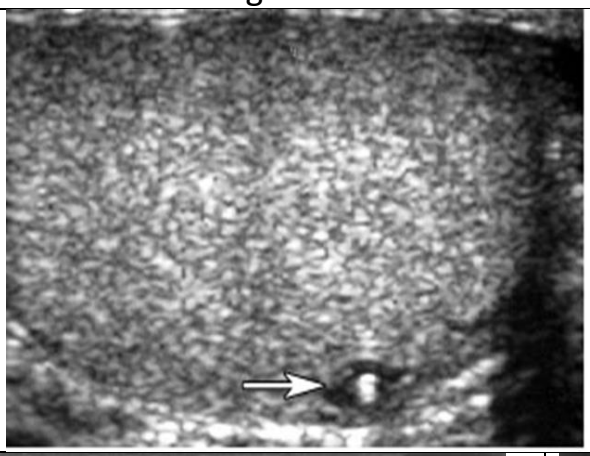
- Fibrous pseudo tumor is a reactive fibrous proliferation of Para testicular tissue

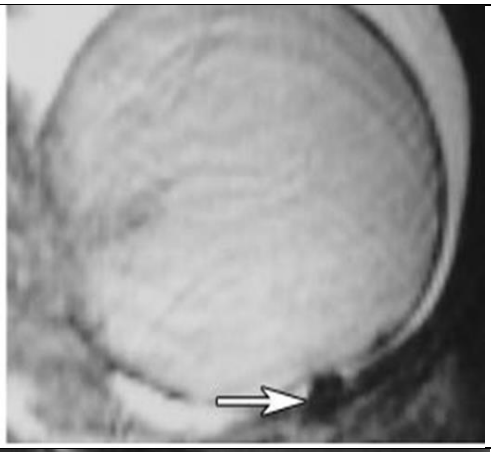
Location:

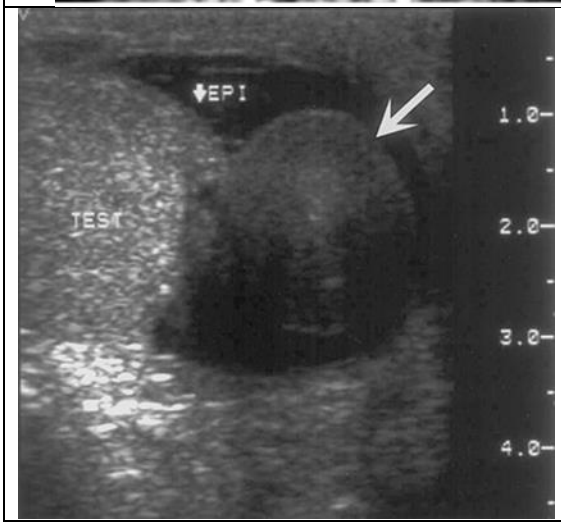
- 75% of cases arise from tunica vaginalis.
- Remainder arising from epididymis, spermatic cord, or tunica albuginea

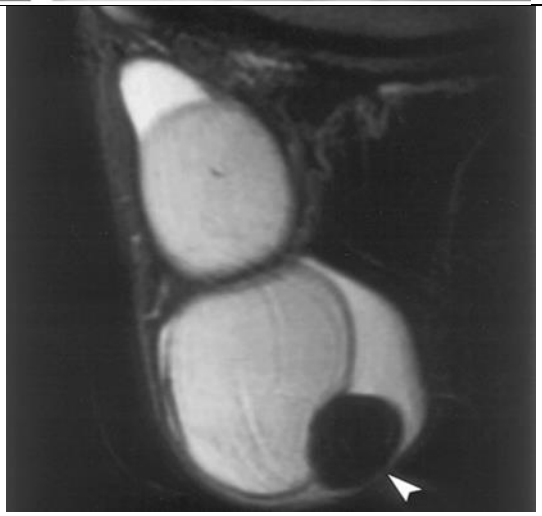
Imaging findings:

- US Central focus of high echogenicity.
- T1 & T2: Low signal





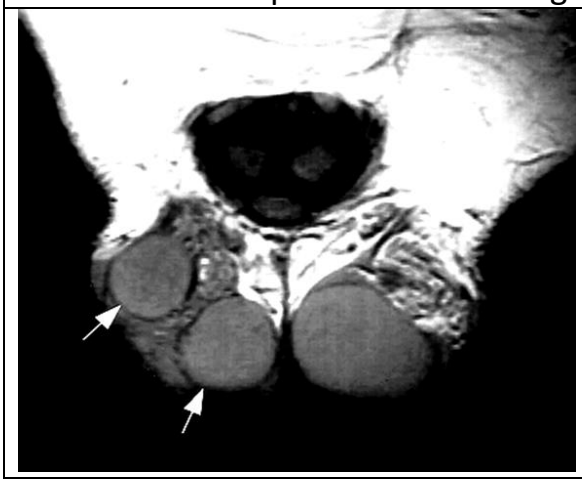




4) Polyorchidism (Supernumerary Testes)

- 75% Intrascrotal, and the patients most often present with a painless scrotal mass.
- 20% inguinal
- 5% Retroperitoneal.

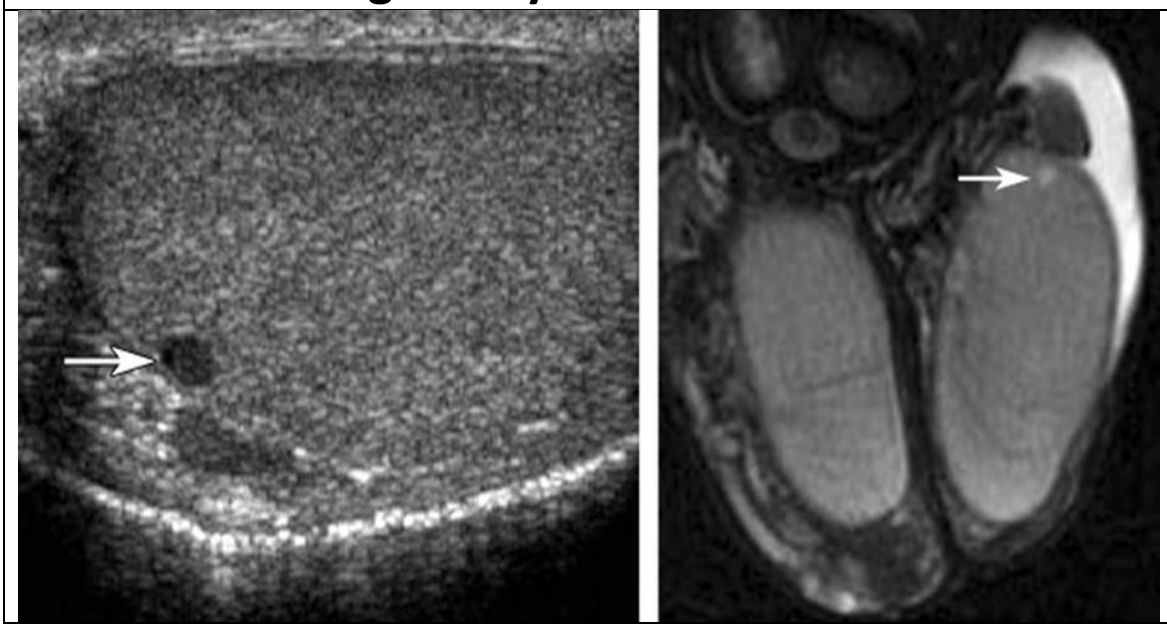
- They often have abnormal spermatogenesis.
- Supernumerary testes are more mobile .
- An increased prevalence of malignancy has also been reported



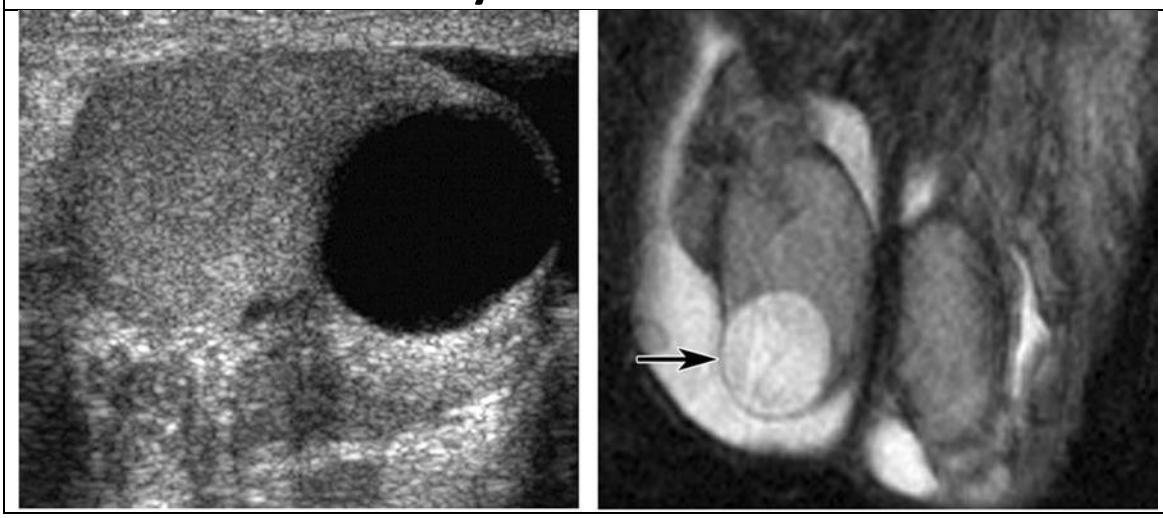
Testicular Cysts

Benign	Malignant
• Tunica albugenia cyst • Tunica vaginalis cyst • Intra-testicular cyst • Tubular ectasia • Cystic dysplasia • Epidermoid cyst • Abscess	• Non-seminomatous GCT • Necrosis or hemorrhage in tumor

❖Tunica albugenia cyst



❖Intratesticular Cyst

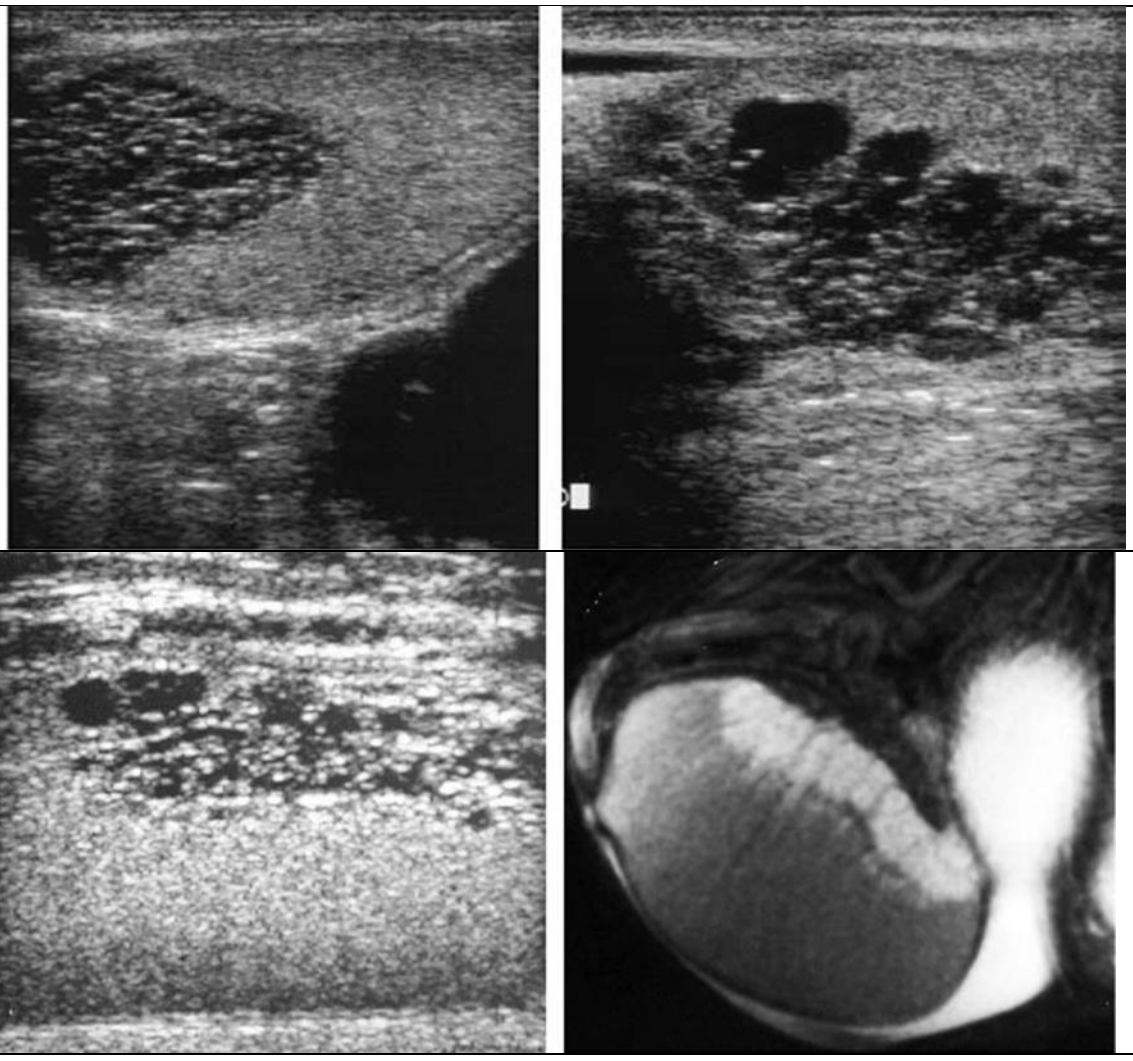


❖Dilated Rete Testis

- Benign condition results from partial or complete obliteration of the efferent ductules, which causes ectasia and, eventually, cystic transformation.
- It represents dilated testicular mediastinal tubules.
- It is often bilateral.
- It is frequently associated with spermatocele.
- It is more common in men > 55 years

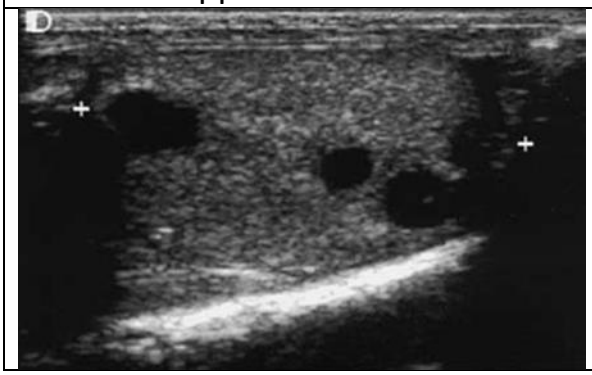
Imaging findings:

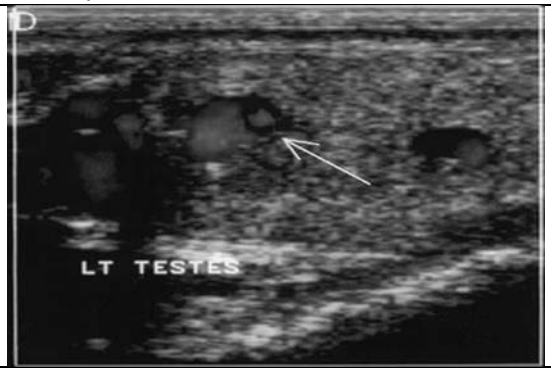
- US: multiple small, cystic or tubular, anechoic structures
- Doppler: No flow / vascularity
- T2: High signal
- +C: No enhancement



❖Intra-Testicular Varicocele

- Intratesticular tubular cystic structures of varying sizes.
- Color Doppler US scan shows flow (arrow) within the tubular structures





❖Intra-Testicular Abscess

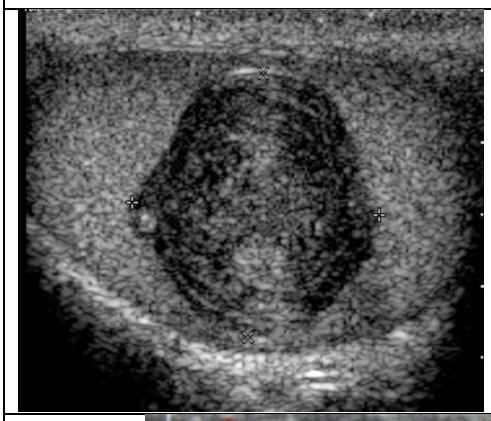
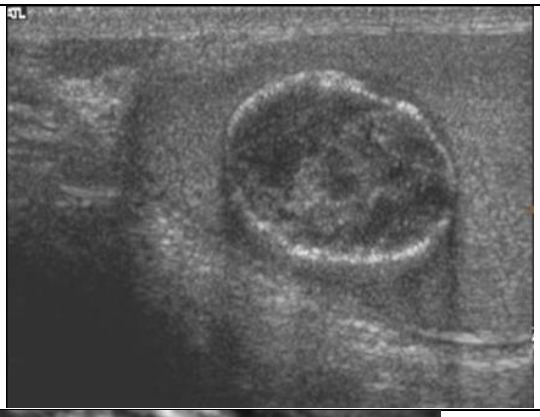
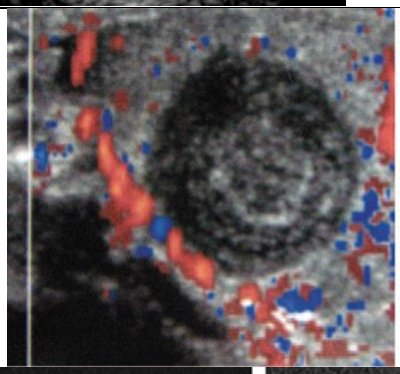
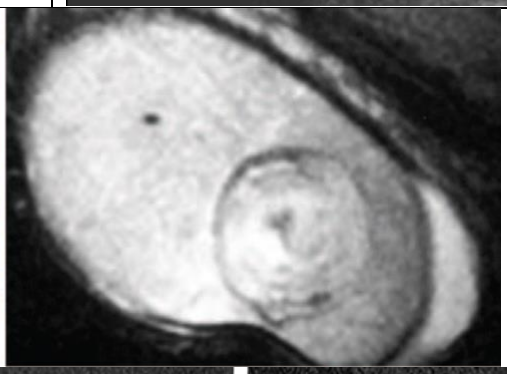
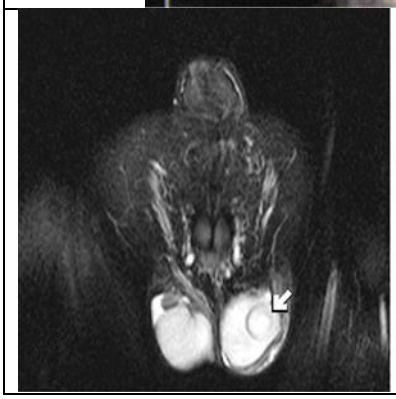
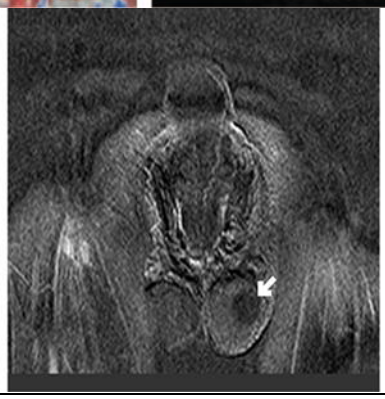
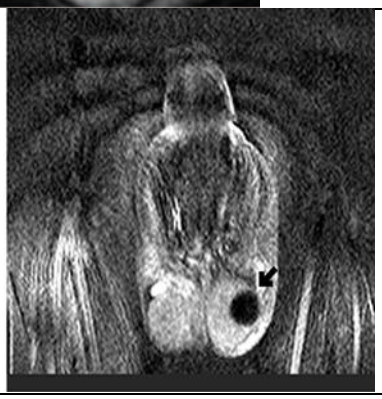
- US: complex hypoechoic mass with an irregular margin. There is no through transmission, but there is a small, associated, reactive hydrocele and skin thickening
- Doppler US: increased vascularity in the surrounding parenchyma. The patient had orchitis, which led to abscess formation.

❖ Epidermoid Inclusion Cyst

- The most common benign intratesticular neoplasm
- Painless mass in younger men and adolescents
- 1–3 cm at discovery.
- Treated by Enucleation rather than orchiectomy

Imaging findings:

- US: Onion ring pattern / Target pattern (marginally calcified mass)
- Doppler: No flow
- MRI: alternating rings of low and high pattern
- +C: No enhancement

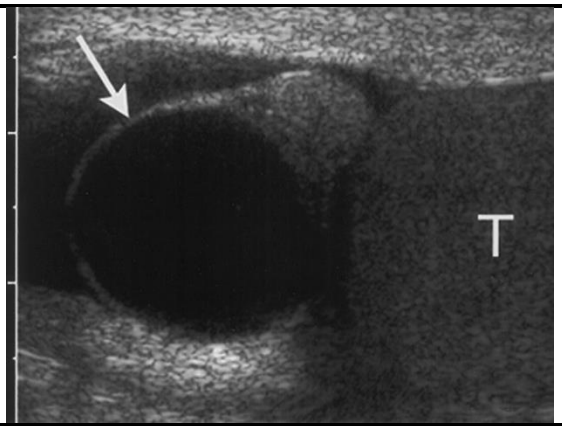
Para- Testicular Cysts

❖ Epididymal Cyst

- Epididymal cyst is the most common of epididymal masses.

US:

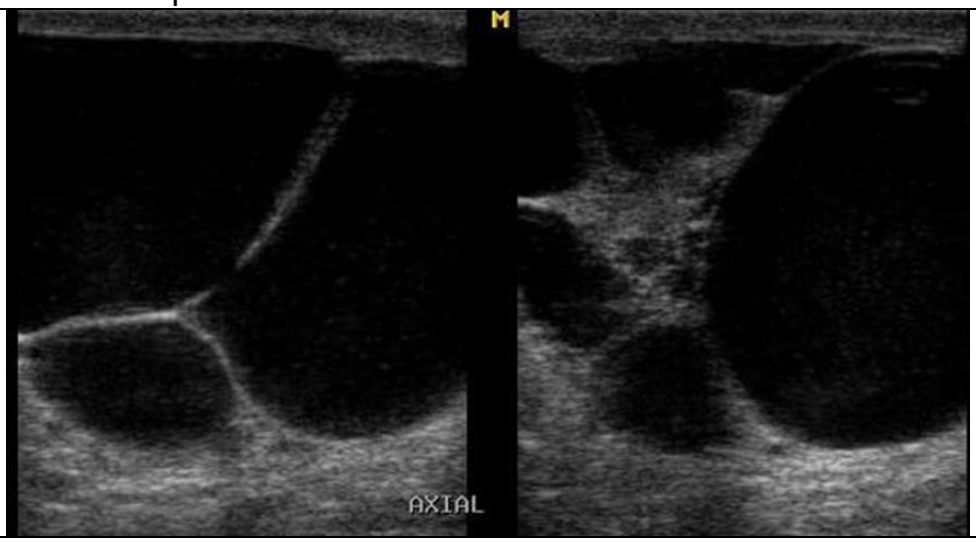
- A cyst within the head of the epididymis
- Anechoic with no internal echoes
- Posterior acoustic enhancement



❖ Spermatocele

- Represents cystic dilatation of tubules of the efferent ductules in the head of the epididymis.

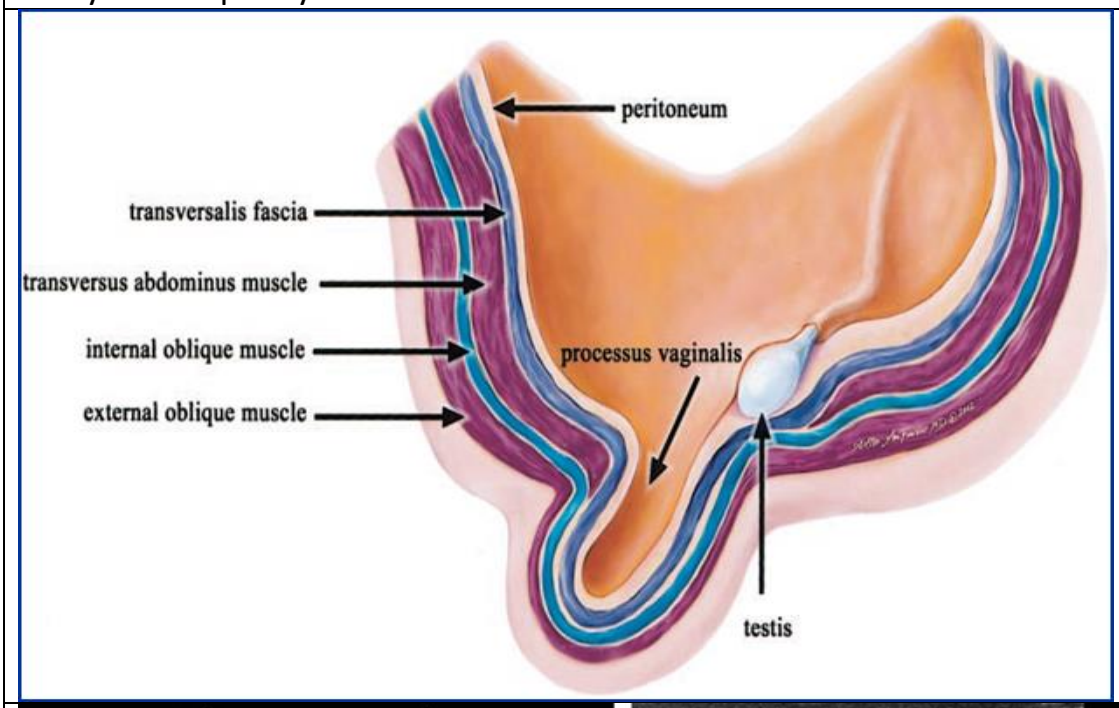
- Well-defined epididymal head cyst
- Low-level internal echoes
- Sometimes septations

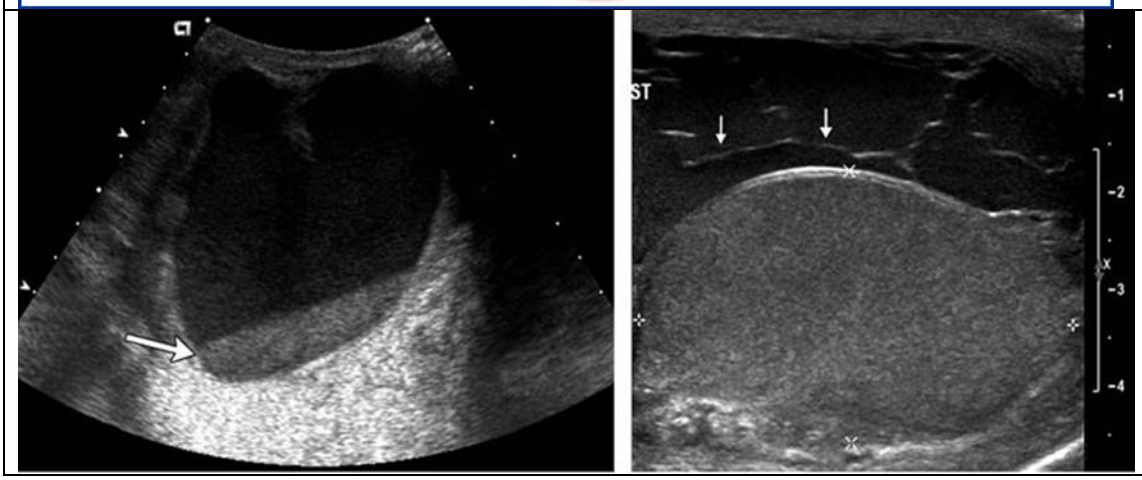


❖ Hydrocele

- Most common cause of painless scrotal swelling

- Causes: trauma- infection- tumor- tortion-idiopathic
- Congenital hydrocele: Patent processus vaginalis
- Hematocele: secondary to trauma- surgery or tumor
- Pyocele: Epididymo-orchitis- abscess





❖ Varicocele

- is the dilatation of pampiniform plexus of veins

Clinical presentation

- Varicocele can be asymptomatic.

If symptomatic presentations include:

- Scrotal mass/swelling
- Scrotal pain
- Testicular atrophy
- Infertility or subfertility

Primary Varicocoele

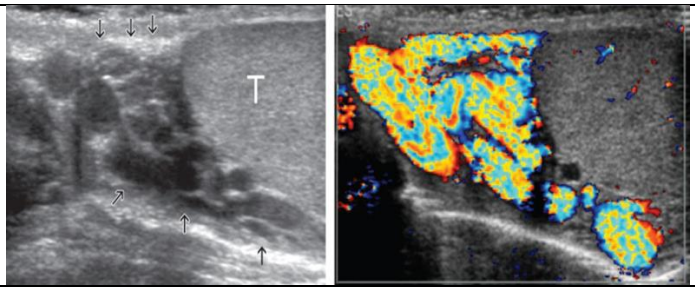
- Most varicocoeles are primary
- Result from incompetent or congenitally absent valves in the testicular vein (internal spermatic vein).
- Left side testicle is much more common (≈85%) than the right.
- This may be due to the shorter course of right testicular vein and its oblique insertion into the IVC which creates less backpressure.
- Bilateral varicocoeles are not uncommon (≈15%).
- Isolated right varicocoeles are rare and should prompt evaluation for a secondary varicocele.

Secondary Varicocoele

- much less common and result from increased pressure in testicular vein due to compression (e.g. extrinsic mass), obstruction (e.g. renal vein thrombus), or splenorenal shunting (portal hypertension).

US findings:

- Dilatation of pampiniform plexus veins >2-3 mm diameter
- Serpentine appearance
- Reversed flow with the Valsalva manoeuvre

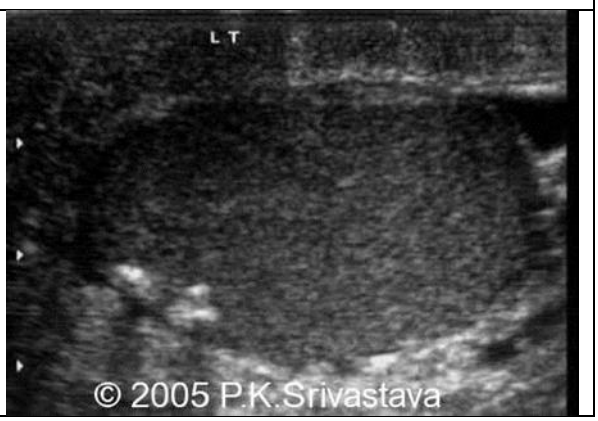


Scrotal Calcifications

Testicular	Extra-Testicular
• Solitary, postinflammatory, granulomatous. • Microlithiasis. • Burned out GCT • Large cell calcifying sertoli cell tumor • Teratoma • Mixed GCT • Sarcoidosis • TB • Chronic infarction	• Tunica vaginalis (scrotal pearls) • Chronic epididymitis. • Schistomiasis.

1) Solitary, Postinflammatory, Granulomatous Testicular Calcification

- Amorphous benign testicular calcification possibly due to some old infection or old trauma.
- Discrete, chunky, highly echogenic foci



2) Testicular Microlithiasis

- Common condition that represents the deposition of multiple tiny calcifications throughout both testes.
- The diagnosis is only made with more than five calcifications are detected.
- In majority of cases testicular microlithiasis is bilateral.

Known associations include:

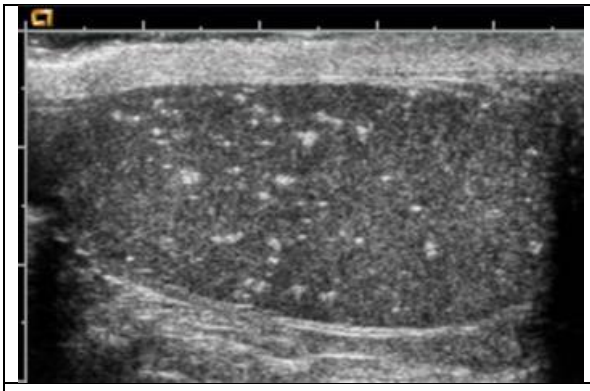
- ✓ Testicular germ cell tumour
- ✓ Kleinfelter syndrome
- ✓ Cryptorchidism
- ✓ Testicular infarct
- ✓ Granuloma
- ✓ Infertility
- ✓ Down syndrome
- ✓ Alveolar microlithiasis

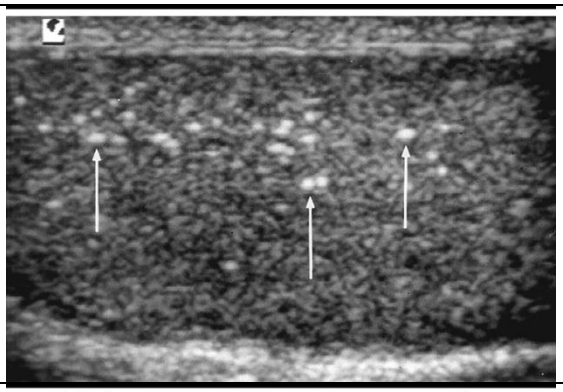
Grading system used on ultrasound:

Grade I: 5-10 microcalcifications
Grade II: 11 to 20 microcalcifications
Grade III: 21 to 30 microcalcifications
Grade IV: >30 microcalcifications

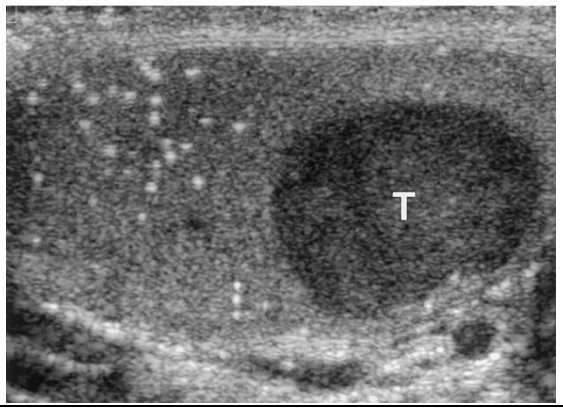
Relation between Testicular microlithiasis and GCT:

- Testicular microlithiasis is in itself asymptomatic and benign.
- A relationship between testicular tumours (in particular germ cell tumours (GCT)) is controversial.
- An 8 fold increased risk of GCT in symptomatic testicles with microlithiasis has been reported (microlithiasis is found in approximately 50% of GCT cases),
- however, no increased risk has been found in asymptomatic testicles.
- As such, screening is unlikely to be beneficial



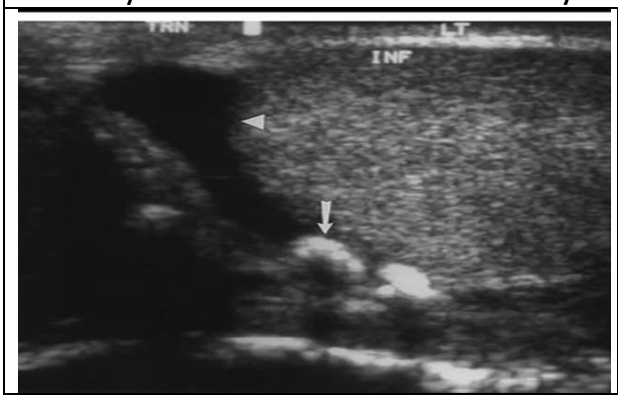


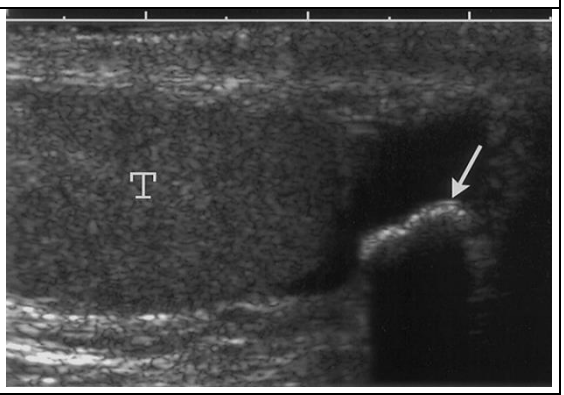
- Longitudinal US image shows a hypoechoic mass pathologically proved to be a seminoma.



3) Scrotal Calculi/ Scrotal Pearls

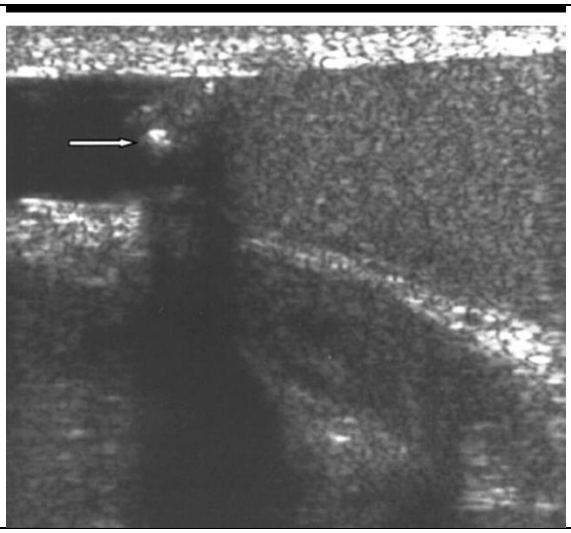
- They are free-floating calcifications within the tunica vaginalis.
- On US scans, they appear as mobile, echogenic calculi with posterior acoustic shadowing.
- They are often associated with hydroceles.





4) Epididymal Calcification

- epididymal calcification (arrow) in the area of the head of the left epididymis



Acute Scrotal Pain

- **Epididymitis and Epididymo-orchitis**
- **Testicular Abscess**
- **Fournier gangrene**

- **Testicular torsion**
- **Testicular infarction.**
- **Appendix testis torsion**
- **Testicular rupture.**

- **Penile Mondor disease**
- **Priapism**

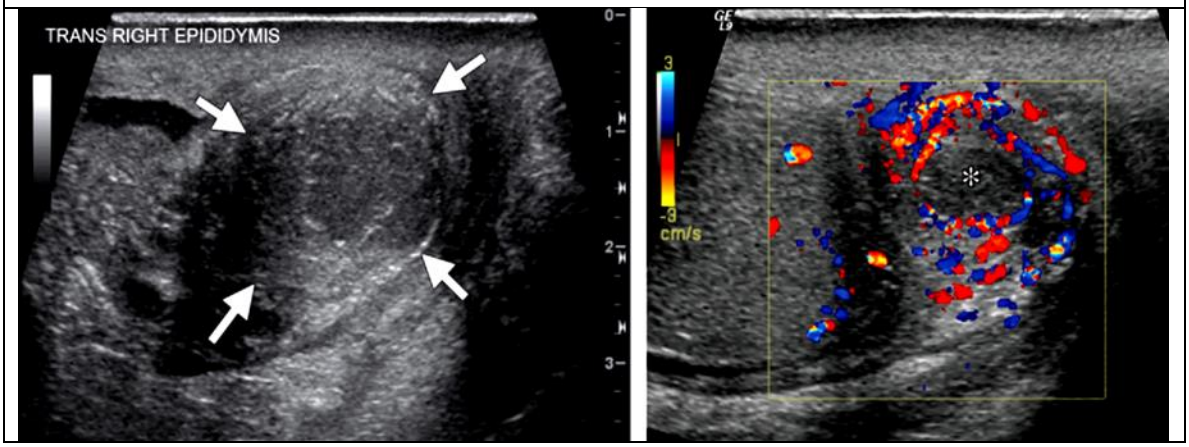
1) Acute Epididymo-orchitis

- Acute Epididymitis and epididymo-orchitis are common causes of acute scrotal pain in young males.
- The infection usually begins in the tail of the epididymis and spreads to the body and head.
- 20%–40% of cases of epididymitis are associated with orchitis, which is thought to be due to direct extension of infection into the testicular parenchyma

- Mode of transimittion: Most cases are caused by sexually transmitted disease or retrograde spread of bacterial infections from the urinary bladder.
- Causative organism:
    - Younger than 35y: Neisseria gonorrhoeae and Chlamydia trachomatis
    - Older than 35y: Escherichia coli

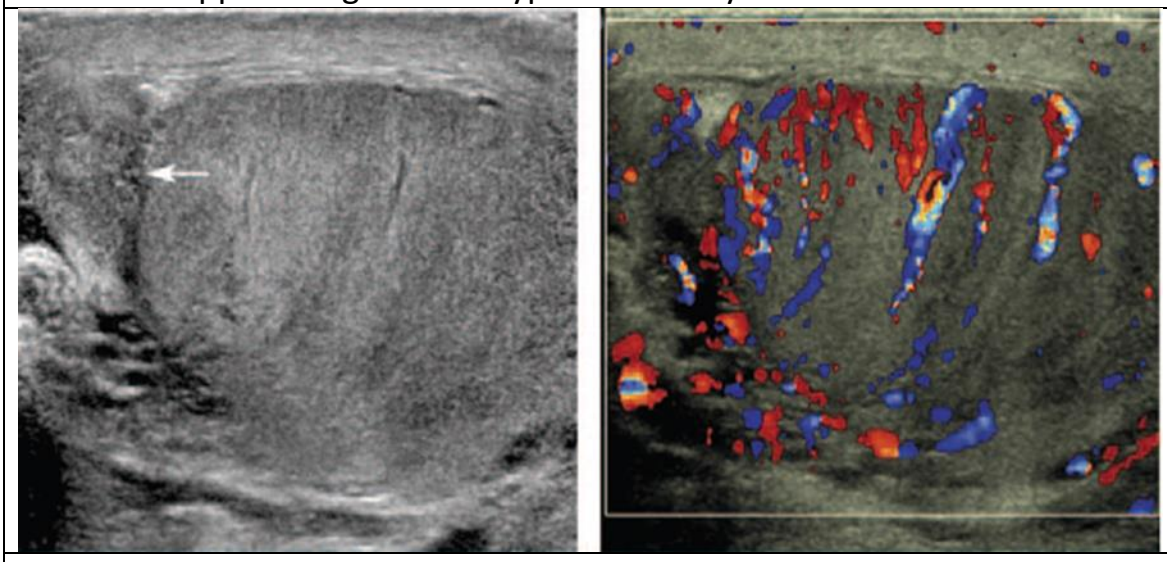
Acute Epididymitis

- Enlarged hypoechoic epididymal tail in the inferior portion of the hemiscrotum.
- Doppler: Increased vascularity of the epididymis.
- The testis is normal.



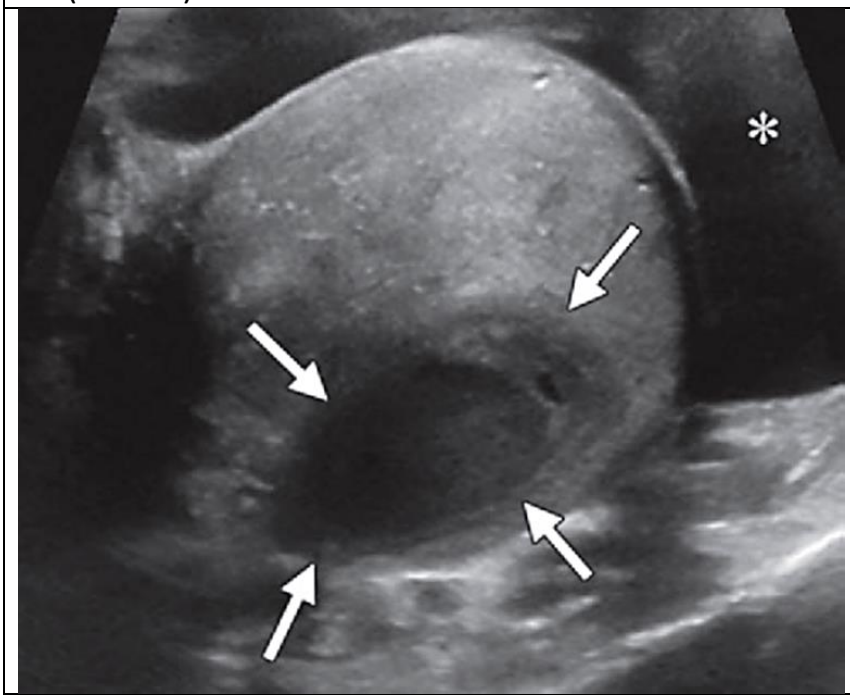
Acute Epididymo-orchitis:

- US: Testis shows heterogeneous low echogenicity and enlargement.
- Color Doppler image shows hypervascularity.



Testicular Abscess:

- A well-circumscribed hypoechoic area in the testicular parenchyma (arrows) with internal low-level echoes



2) Testicular Torsion

- Testicular torsion and epididymo-orchitis commonly present with pain.
- The main role of US is to differentiate acute testicular torsion, which is a surgical emergency, from epididymo-orchitis.

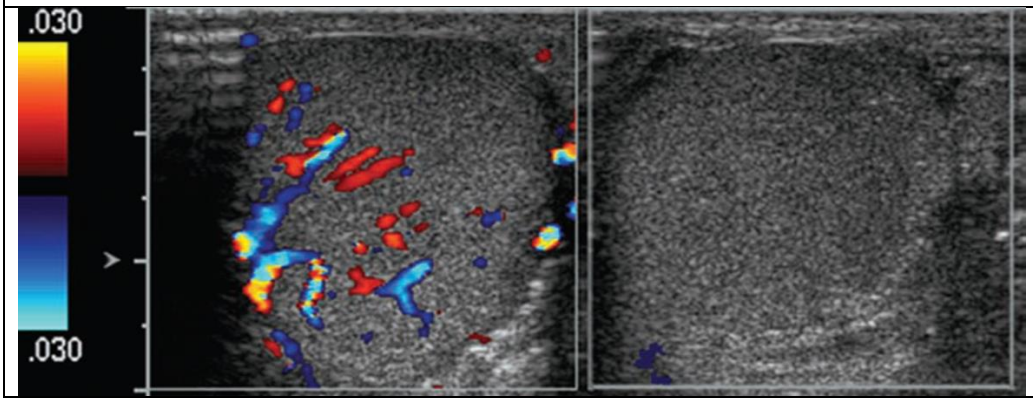
2 types of torsion:

- Intravaginal torsion (ie, torsion distal to the attachment of the tunica vaginalis) accounts for most cases of testicular torsion.
- Extravaginal torsion (ie, torsion proximal to the attachment of the tunica vaginalis) accounts for 10% of cases of testicular torsion

- Most cases are spontaneous.
- The "bell-clapper" deformity, an abnormally high attachment of the tunica vaginalis, is present in 12% of males and predisposes them to intravaginal testicular torsion

- Age: most commonly 12 - 18 years but can occur at any age.
- Cl/P: Patients with acute torsion present after a sudden onset of pain followed by nausea, vomiting, and a low-grade fever.
- Examination: swollen, tender, and inflamed hemiscrotum. The cremasteric reflex is usually absent, and the pain cannot be relieved by elevation of the scrotum.
- Pathology: Testicular torsion causes venous engorgement that results in edema, hemorrhage, and subsequent arterial compromise, which results in testicular ischemia.

- US: Enlarged testis with a hypoechoic appearance.
- Doppler:
    - Absent arterial and venous flow
    - Increased RI on affected side
    - Diminished or reversed diastolic flow



3) Fournier Gangrene

- Fournier gangrene is a necrotizing infection that involves both superficial and deep fascial planes.
- Urologic emergency that must be recognized early because of its high mortality.
- Predisposing factors: Diabetes mellitus and alcoholism.

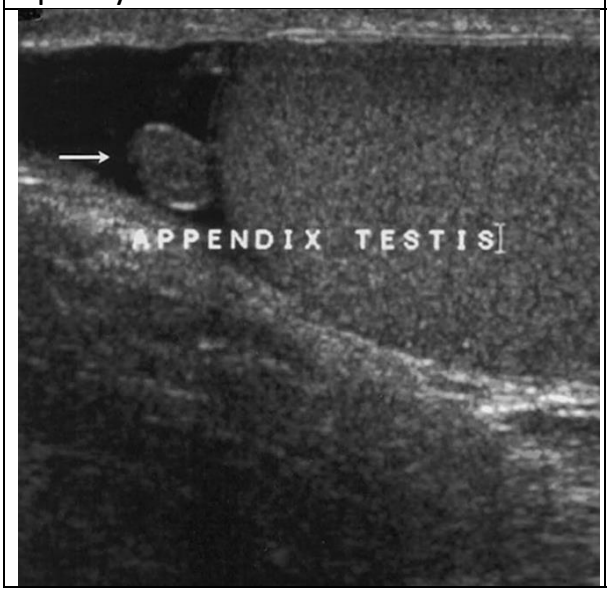
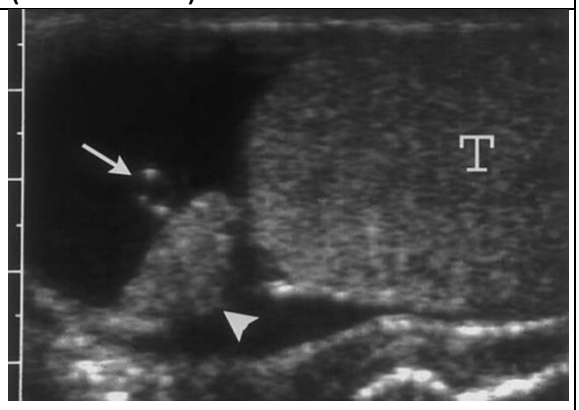
- CT may depict small amounts of gas in soft tissues and fluid collections in the deep fascial plane.
- CT is the modality of choice in patients with Fournier gangrene because it may depict the source of infection and its pathways of spread

Testicular Appendages

<u>These are remnants of embryonic ducts.</u>

<u>4 testicular appendages:</u>

- The appendix testis
- The appendix epididymis
- The vas aberrans
- The paradidymis

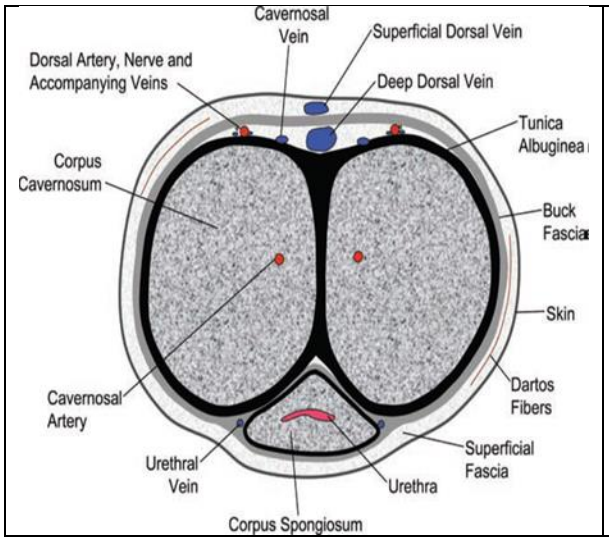
The appendix testis is attached to the upper pole of the testis in the groove between the testis and the epididymis.	Appendix epididymis (arrow) projecting from the normal triangular epididymal head (arrowhead).
	

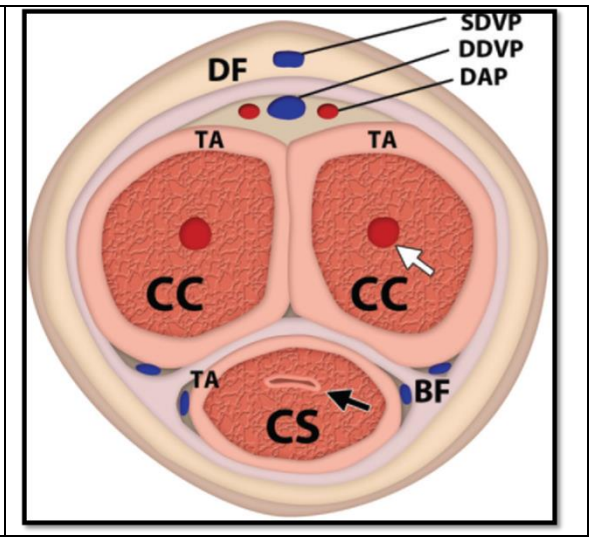
Male Genital System

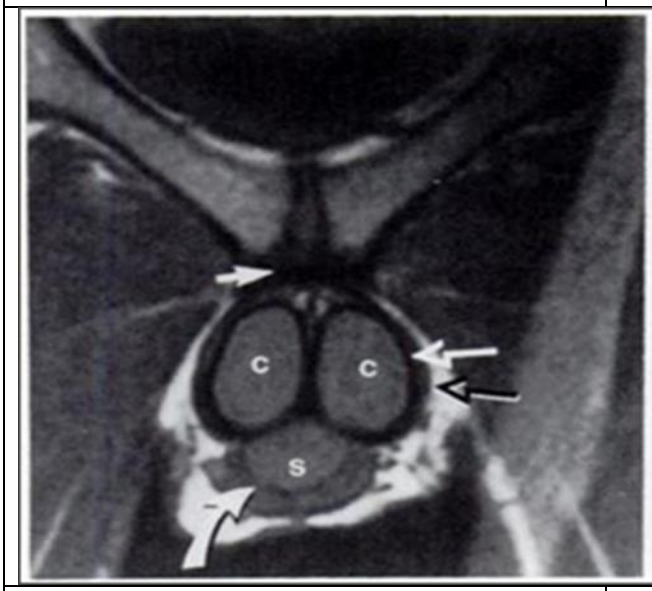
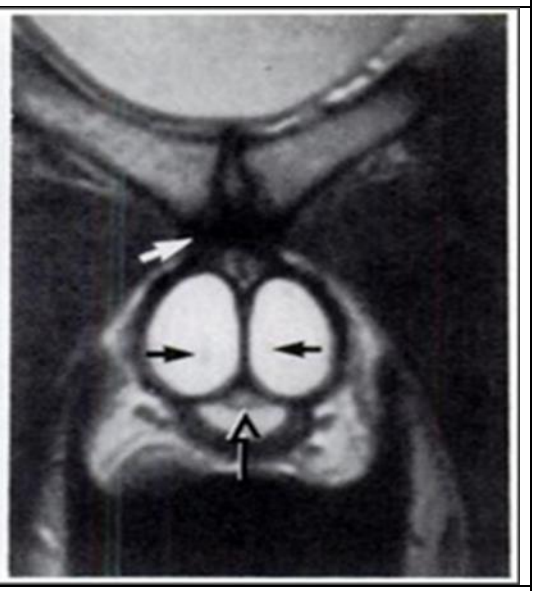
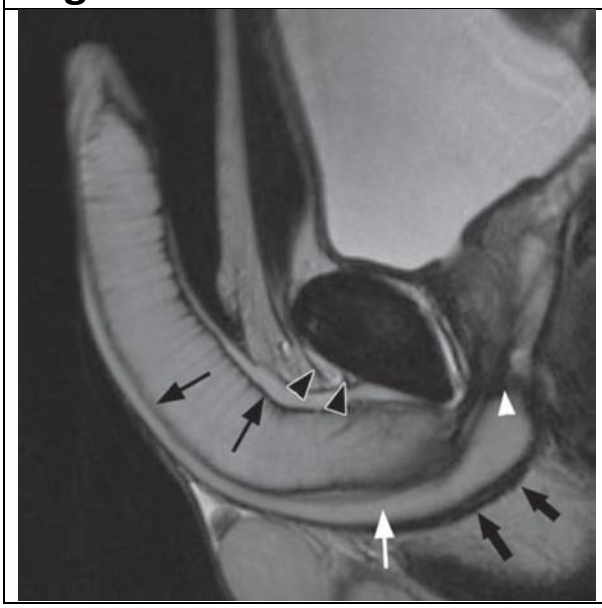
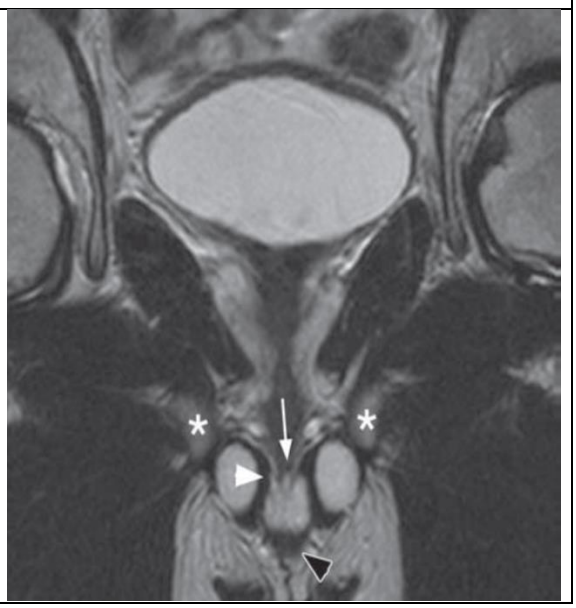
C- Penis

Penile Anatomy

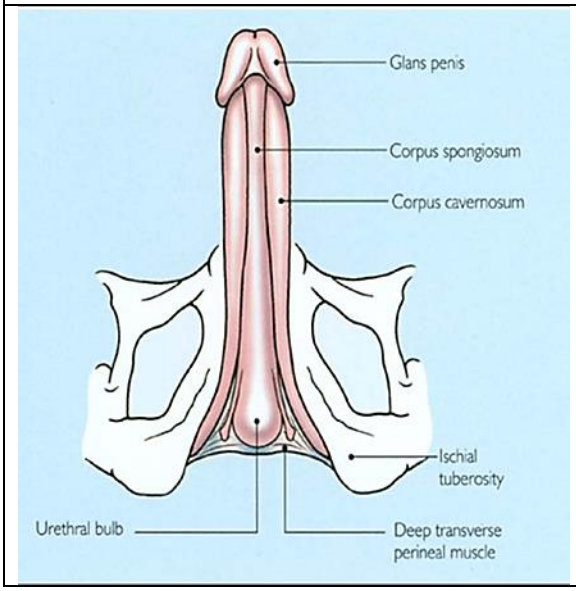
- ***Two corpora cavernosa (dorsal).***
- ***Single corpus spongiosum (ventral) surrounding urethra and forms the bulb proximally, glans distally.***
- ***Intercavernosal septum***
- ***Tunica albuginea***
- ***Buck fascia***





Axial T1	Axial T2
	
Sagittal T2	**Coronal T2**
	

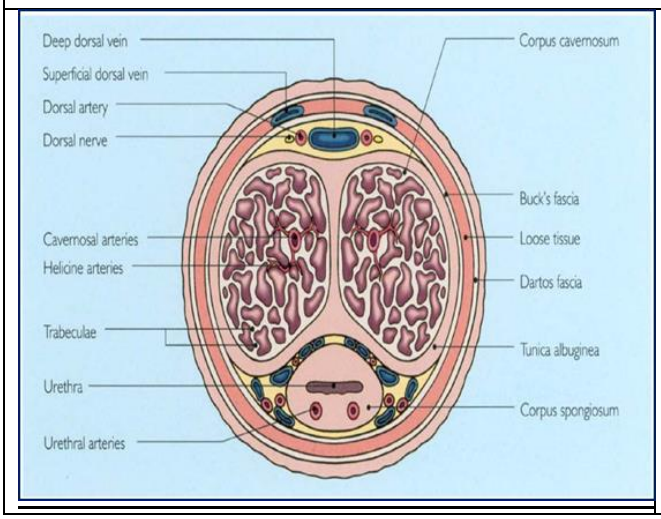
- **Transverse Perineal muscle.**
- **Ischeocavernous muscle**

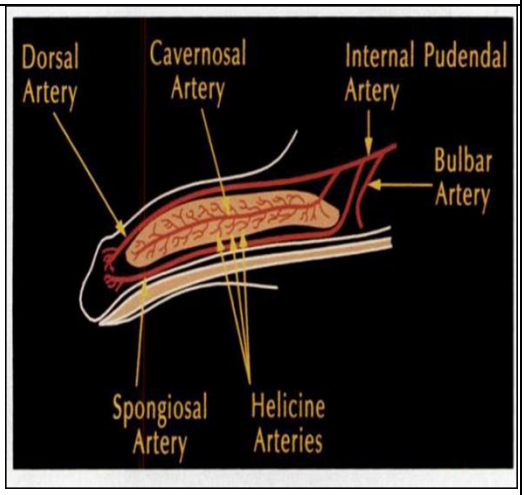


❖Arterial Supply:

Internal Pudendal artery:

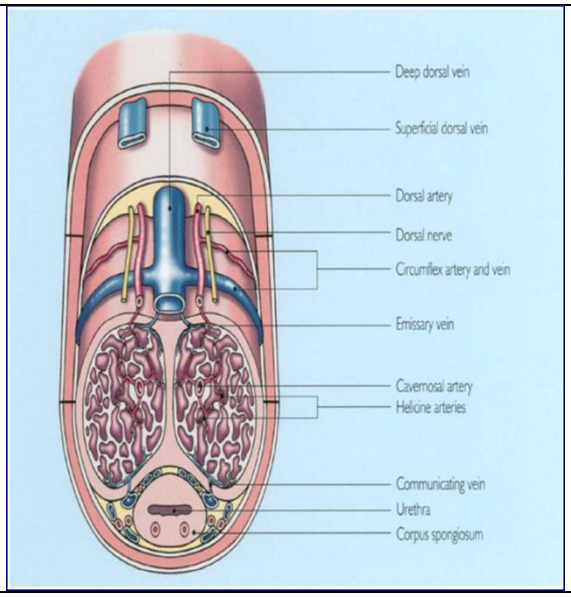
- Bulbar A: Proximal shaft.
- Spongiosal A : corpus spongiosum
- Cavernosal A: centrally within the corpus cavernosum
- Dorsal penile A: along the dorsal side of the penis lateral to the mildline dorsal vein at skin, subcuteneous tissue and glans.
- Helicine branches sinusoids





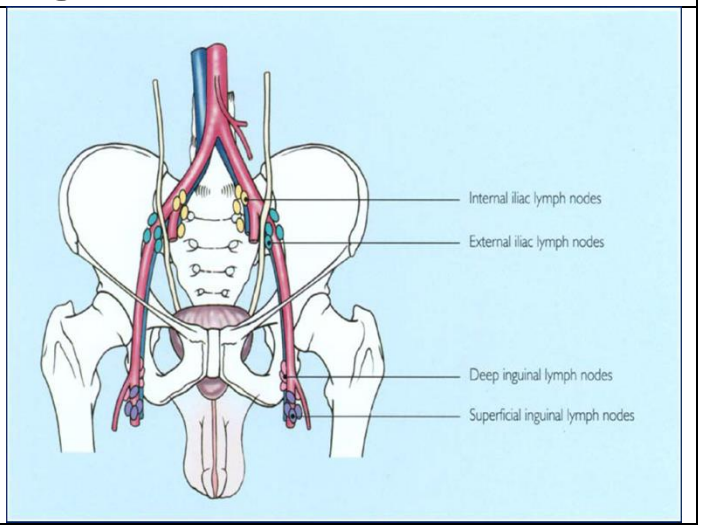
❖Venous Drainage:

- The sinusoidal spaces → emissary veins → circumflex veins → deep dorsal v.
- The emissary veins may also drain directly → deep dorsal vein.
- Distal corpora cavernosa, skin and glans → Superficial dorsal veins
- Proximal corpora covernosa → cavernosal veins directly into periprostatic pelxus.



❖ Lymphatic Drainage

- **Superficial and deep inguinal LNs**
- **Internal and external iliac LNs**
- **Paraaortic LNs**



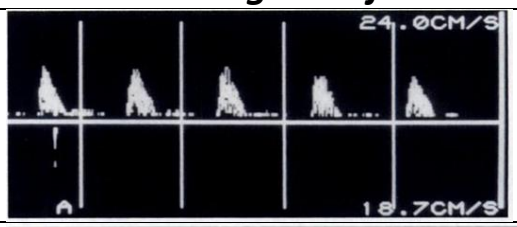
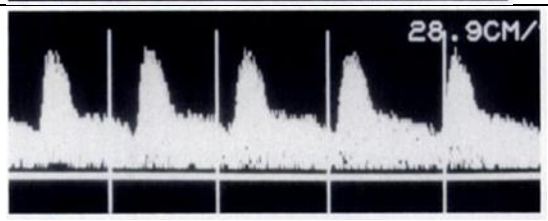
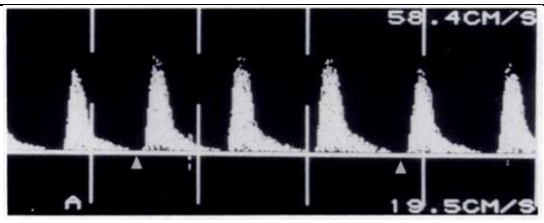
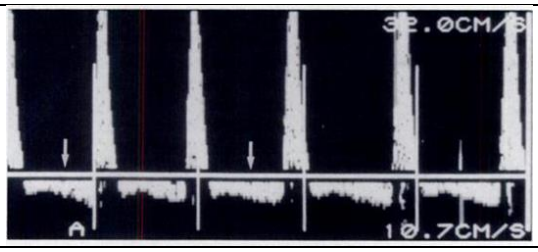
Erectile Dysfunction

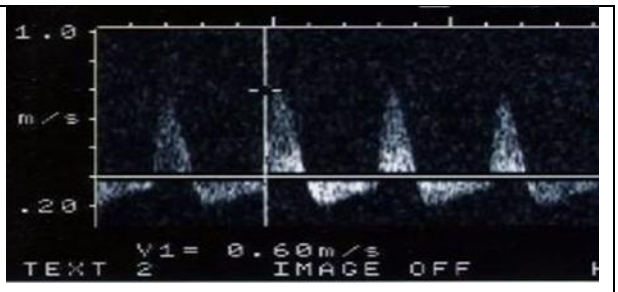
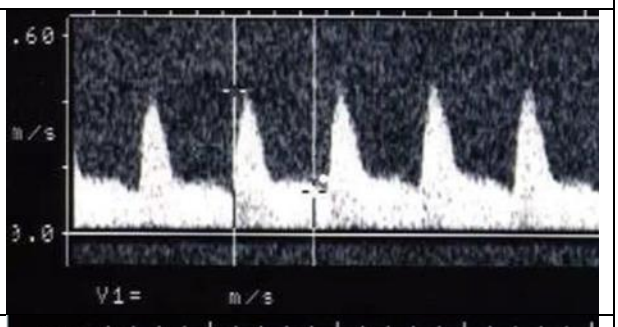
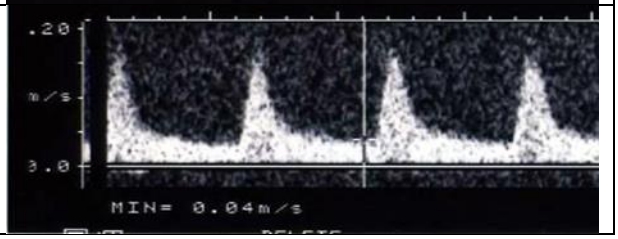
Normal erectile function need:

- Psychological Health.
- Intact neural pathways to and from the brain… DM, MS, Pelvic surgery
- Normal endocrinal balance… Hypogonadism- low testesterone
- Normal smooth muscles. Aging and/or ischemia may result in degeneration of smooth muscle cells, thereby impairing the ability to respond to vasodilator signals.
- Normal cavernosal sinusoids. Peyronie's Disease.
- Adequate arterial supply: DM, Atherosclerosis, smoking.
- Normal venous pattern

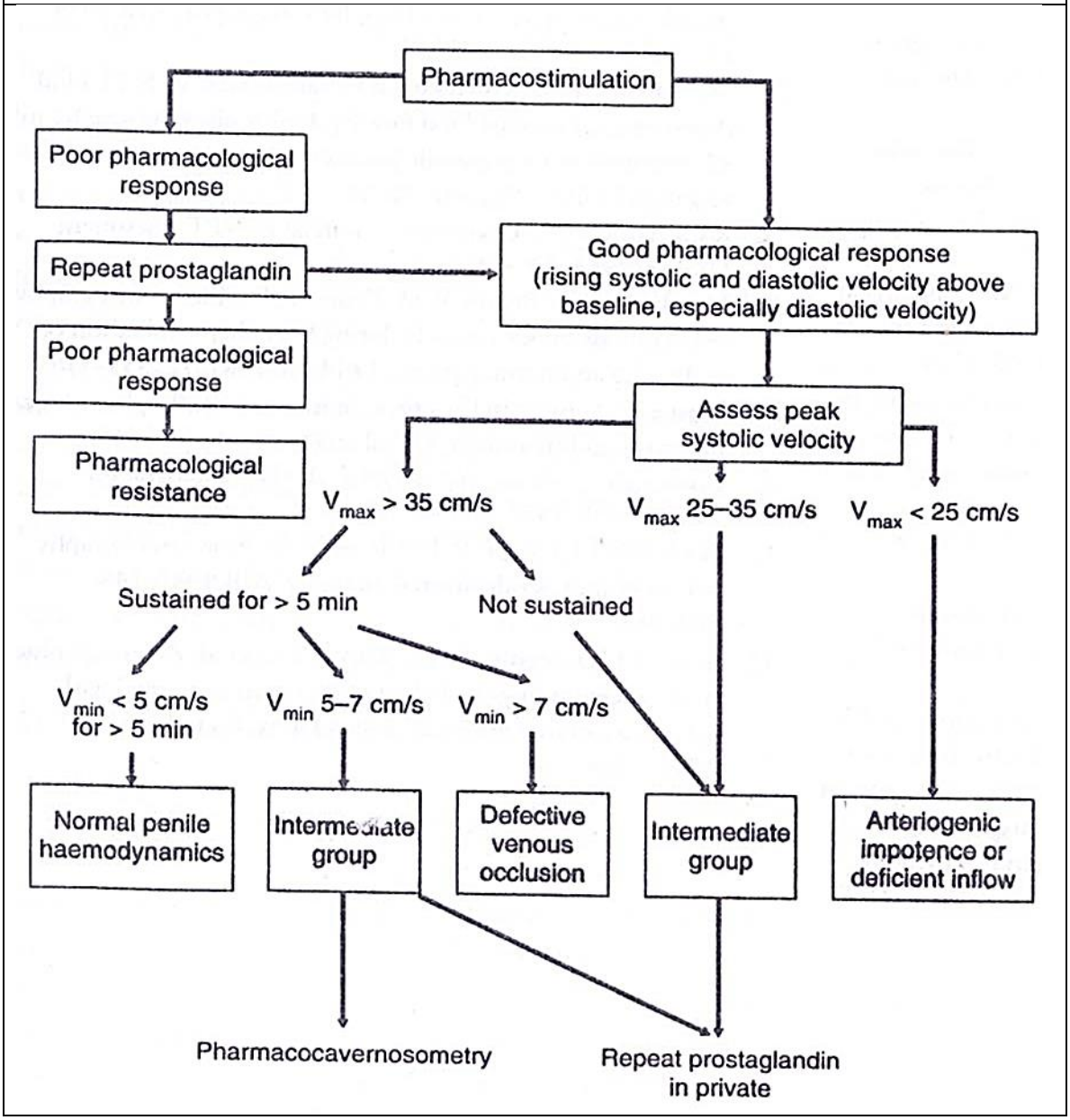
Pharmacological induced erection:

- Quite dark room.
- High-frequency linear (7-10 MHz) probe.
- Supine position.
- Examination of penile artery in preinjection state is not necessary.
- Tourniquet at the penile base may be used for 3 min.
- A vasoactive agent is injected into the corpus cavernosum near the base of the penis at one side => smooth m relaxation.
    - Papaverine: 30 mg
    - Prostaglandin E1 (PGE1): 10-20ugm
- Both cavernosal arteries are alternatively scanned for PSV and EDV every 3 min.
- The patient informed about the prolonged erection.

❖ ***Spectral waveforms in the cavernosal artery during normal progression of erection after vasoactive agent injection.***	
<u>Flaccid phase:</u> High resistance. Low PSV Absent diastole	
<u>Early after injection</u> Decrease peripheral resistance Abrupt increase in PSV High EDV > 10 cm/sec. Minimal tumescence	
<u>Increased sinusoidal filling (Increased intracavernosal pressure).</u> Increased PSV EDV reaches zero	
<u>Penile rigidity:</u> PSV reach the maximum. Reversed diastole	

<u>Normal values:</u> PSV > 35 cm/s Reversed diastole EDV < 5 cm/s Sustained over a period > 5 min.	
<u>Venous Leakage:</u> EDV > 7 cm/s	
<u>Arterial Insufficiency:</u> PSV < 25 cm/s	

Suggested practical diagnosis pathway of pelnile Doppler:



Penile Fracture

Mechanism of injury:

- Penetrating or blunt trauma.
- Most blunt traumatic injuries are to the erect penis from sudden lateral bending.
- Most often occurs during sexual intercourse
- Sometimes occurs during masturbation or after falling on the erect penis

- Penile fracture occurs when one or both corpora cavernosa rupture, a result of a tear in the tunica albuginea, which is one of the strongest fascia in the human body.

- MRI can be a useful diagnostic tool in the evaluation of patients with acute penile fracture.

Clinical manifestations:

- An audible crack, sudden onset of pain,
- Immediate loss of erection
- Rapid swelling, widespread ecchymosis,
- Deviation toward the side opposite the injury are characteristic manifestations of acute penile fracture
- Hematuria or dysuria may be present in patients with associated urethral injury.

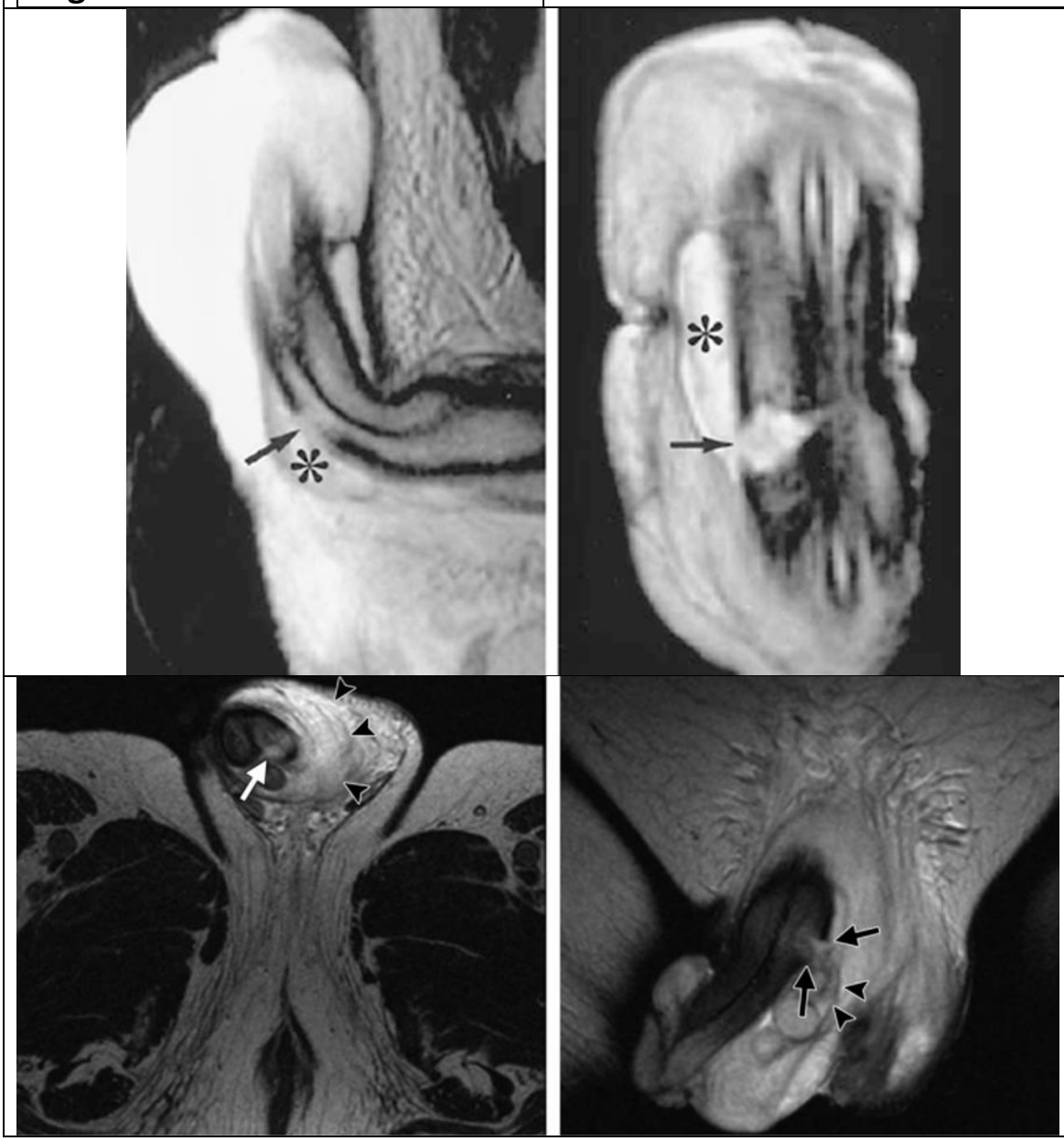
Location:

- The fracture usually occurs unilaterally
- in the distal two-thirds of the penis
- Typically involves less than one-half of cavernosal circumference

A-Tear of the tunica albuginea

- Focal interruption of the low-signal-intensity tunica albuginea (arrow)
- Surrounding hematoma (*) in ventral aspect of corpus cavernosum.

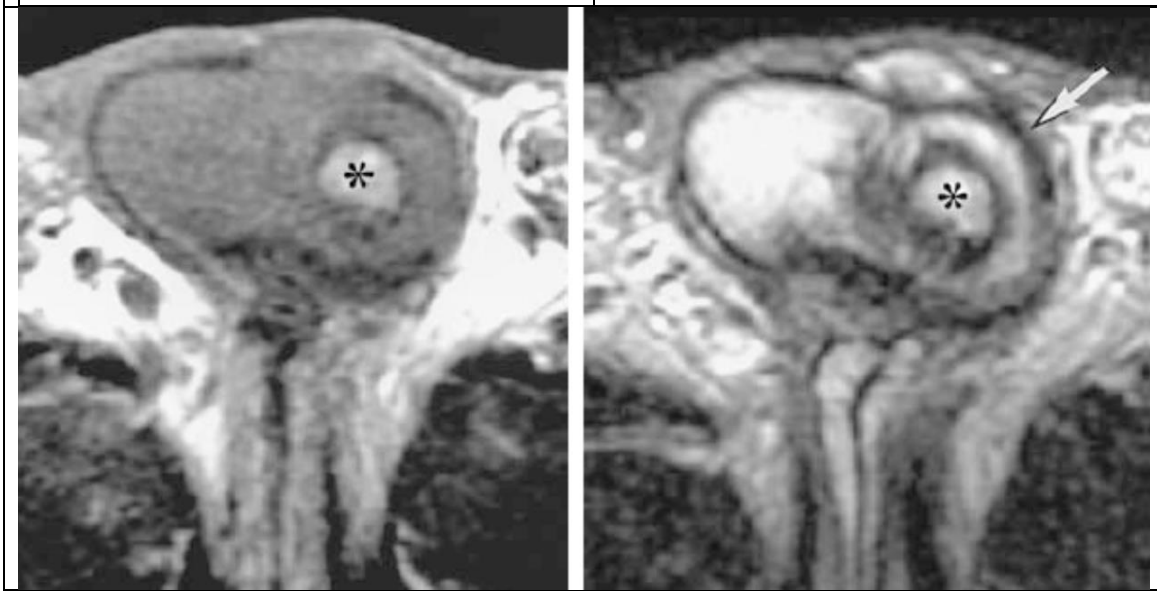
Sagittal T2	Coronal T2



B- Intracavernosal Hematoma:

- Small, round hematoma with high signal intensity on T1 & T2 WIs in the left corpus cavernosum.
- Intact, low-signal-intensity tunica albuginea (arrow).

Axial T1	Axial T2



C- Extratunical Hematoma

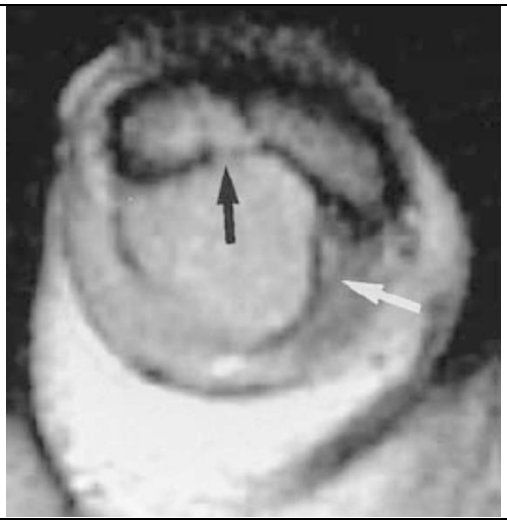
- Small, well-marginated, high SI hematoma in the ventral aspect of the right corpus cavernosum (arrow); outside tunica albuginea.
- Intact low-signal-intensity tunica albuginea.

D- Urethral Rupture

- Tunical tear in the ventral aspect of the left corpus cavernosum (arrowhead).
- A large hematoma adjacent to the tear (H)
- Disruption of the corpus spongiosum and urethra (arrow)

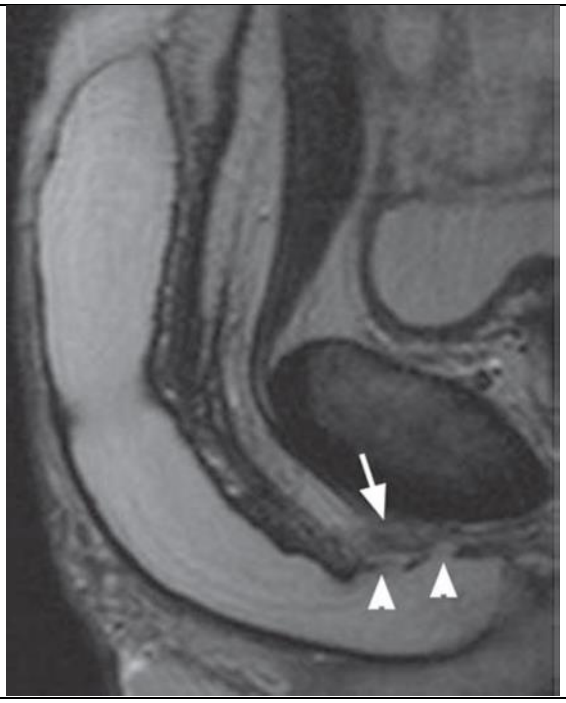
E- Corpus Spongiosal Rupture

- Tear of the tunica albuginea in the ventral aspect of the right corpus cavernosum (black arrow).
- Hematoma is seen displacing the corpus spongiosum (white arrow) and the urethra inferiorly and to the left.



F- Suspensory Ligament Rupture

- Sagittal T2: heterogeneous area inferior to the inferior pubic ramus (arrow)



Peyronie Disease

- One cause of erectile dysfunction that is well depicted at MRI.
- Fibrous plaques at the tunica albuginea.

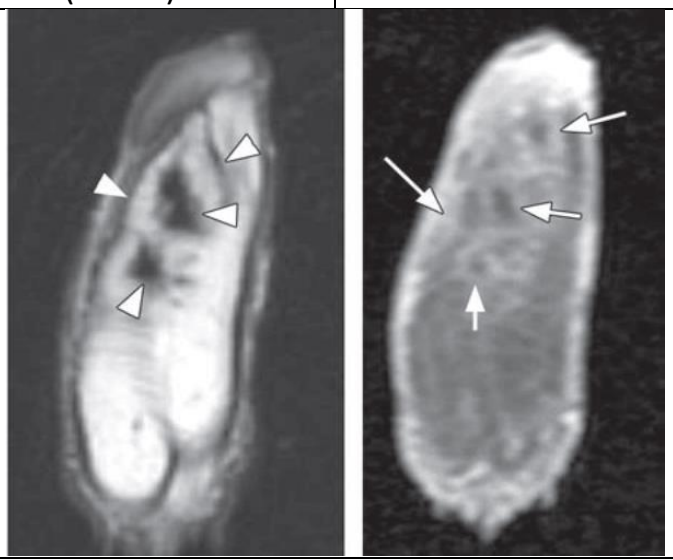
MRI findings:

- Low SI areas of thickening in the tunica albuginea with both T1 and T2.
- Gadolinium-based contrast material to show active inflammation.

2 Clinical Phases:

- An acute phase (12–18 months):
  - Pain during erection.
  - Sometimes flaccidity during intercourse
- A chronic phase:
  - Pain is less conspicuous
  - Penile deformity is dominant—typically a dorsal angulation but sometimes ventral or lateral
  - Often associated with shortening.

Coronal T2	Coronal T1+C
Peripheral plaque in the distal corpus cavernosum (arrow)	mild peripheral enhancement



Penile Neoplasms

- Rare neoplasm in the developed world.
- Age: 6th and 7th decades of life.

Risk factors:

- Uncircumcised men: risk is 3 times higher.
- Poor hygiene: Accumulation of smegma and other irritants.
- Chronic inflammatory conditions
- Smoking
- Human papilloma virus.

Pathologic Considerations:

- Primary neoplasms of the penis can be classified into :
- Squamous cell carcinoma: more than 95%
- Sarcoma: Kaposi sarcoma, leiomyosarcoma, and rhabdomyosarcoma
- Melanoma.
- Basal cell carcinoma
- Lymphoma.
- Metastases : colon, rectum, stomach, bronchus, and thyroid

❖ 2 staging systems :

Jackson Classification of Penile Carcinoma

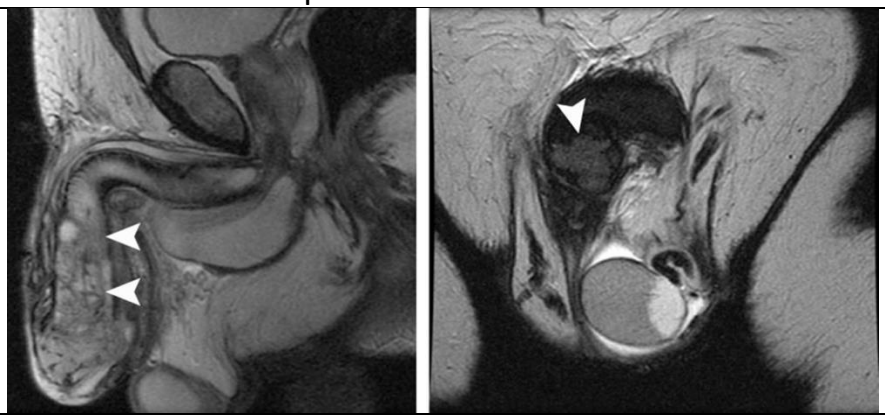
Stage	Involvement
1	Confined to the glans penis
2	Invasion of the shaft or corpora
3	Operable inguinal lymph node metastasis
4	Invasion of adjacent structures, inoperable inguinal lymph node metastasis

TNM Classification of Penile Carcinoma

Stage	Description
Tumor (T)	
Tx	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma in situ
T1	Invasion of subepithelial connective tissue
T2	Invasion of one or more corpora
T3	Invasion of urethra or prostate gland
T4	Invasion of other adjacent structures
Lymph node (N)	
Nx	Regional lymph node cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in a single superficial inguinal lymph node
N2	Metastases in multiple or bilateral superficial inguinal lymph nodes
N3	Unilateral or bilateral metastases in deep inguinal or pelvic lymph nodes
Metastasis (M)	
Mx	Distant metastasis cannot be assessed
M0	No evidence of distant metastasis
M1	Distant metastasis

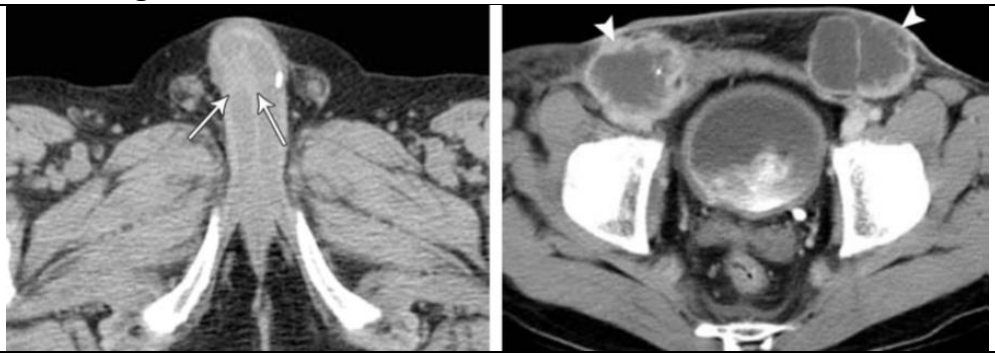
❖Imaging of Primary Tumor

- MR imaging is superior to CT in the evaluation of primary tumors due to its superior soft-tissue resolution, multiplanar capability, and excellent spatial resolution in the assessment of superficial structures.
- T2 and gadolinium-enhanced T1 sequences are the most useful in defining the local extent of a penile neoplasm.
- The depth of tumor invasion and involvement of the tunica albuginea, corpora, or urethra can also be determined.
- Primary penile cancers are most often solitary, ill-defined infiltrating tumors
- T1 and T2: hypointense relative to the corpora
- +C: The tumor enhance on gadolinium-enhanced images, although to a lesser extent than the corpora cavernosa.



❖Imaging of Lymph Nodes

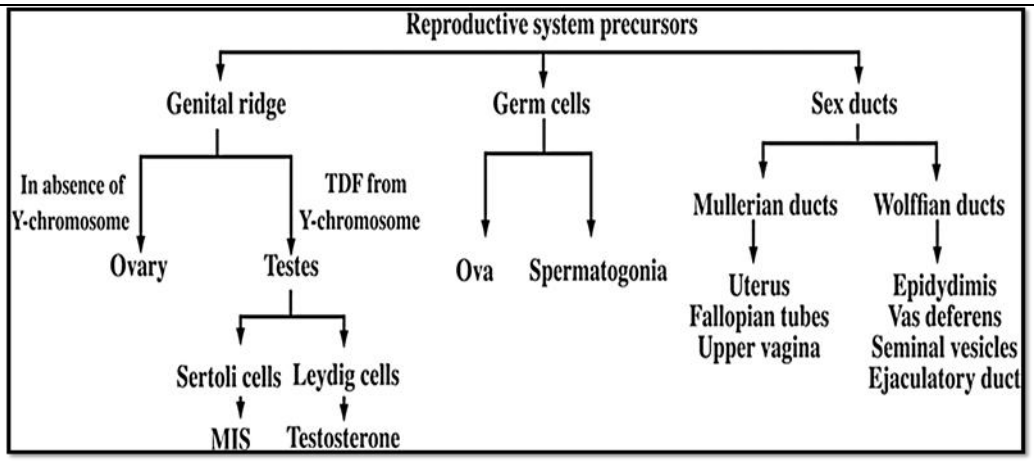
- The presence and degree of lymph node involvement is the most important prognostic indicator.
- Bilateral Inguinal metastatic LNs



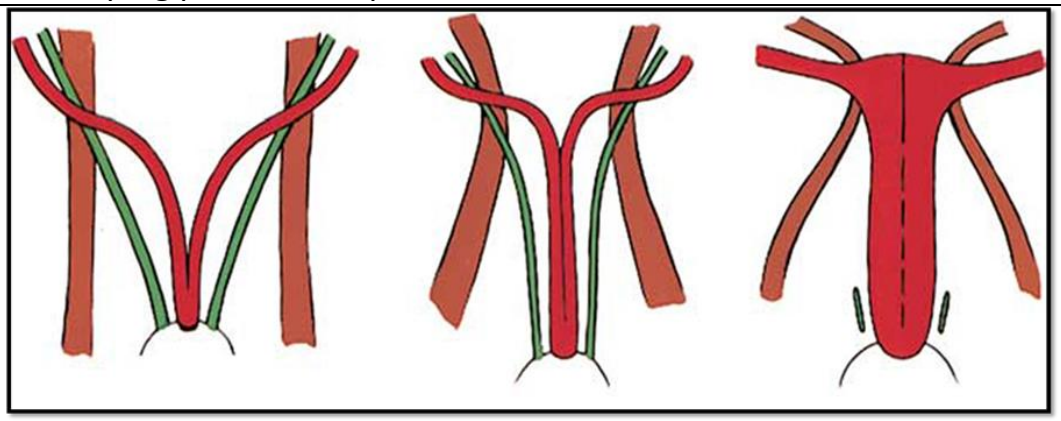
Female Genital System

Uterus

Embryology

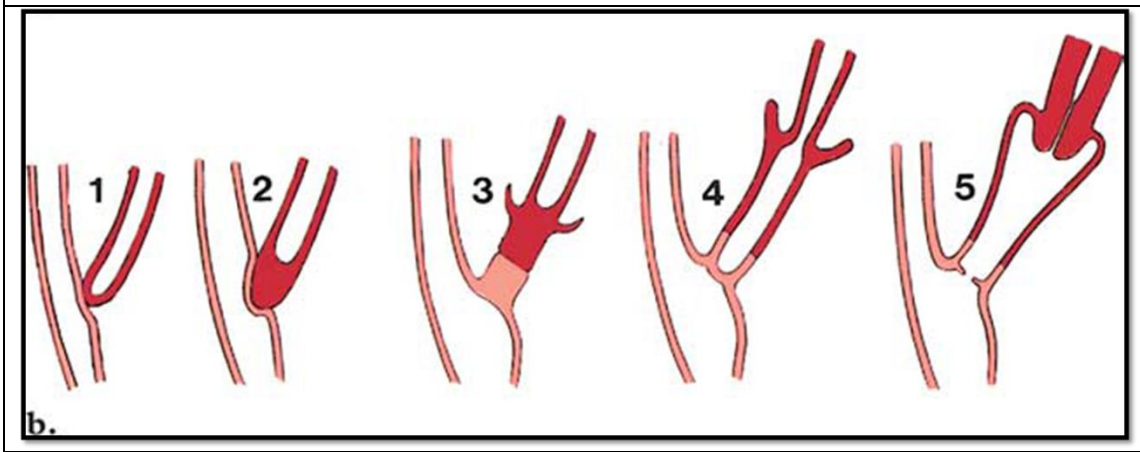


- At 6 weeks of development, the male and female genital systems are indistinguishable in appearance, constituting two sets of paired ducts: the paramesonephric (müllerian) ducts and the mesonephric (wolffian) ducts.
- In the absence of the testis-determining factor of the Y chromosome => the mesonephric ducts begin to degenerate and form a matrix for the developing paramesonephric ducts.



- Both müllerian ducts (red area) fuse on the midline to form the uterus and upper four-fifths of the vagina.
- The proximal parts of the duct remain unfused and open into the peritoneal cavity to give rise to the fallopian tube.
- The wolffian ducts (green areas) regress. The distal remnant of the wolffian duct forms the Gartner duct.

❖ Vagina:

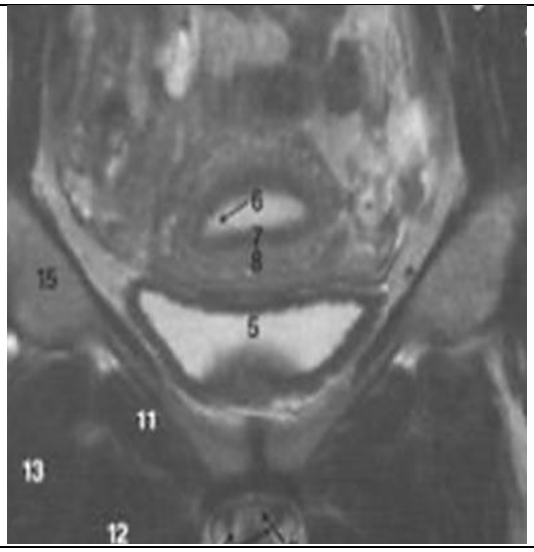


- The uterovaginal canal (red area) reaches the urogenital sinus (pink area)
- The vaginal plate develops (2), proliferates (3), and undergoes canalization (4).
- The vagina is formed by both the müllerian ducts and the urogenital sinus (5).

MRI Zonal Anatomy

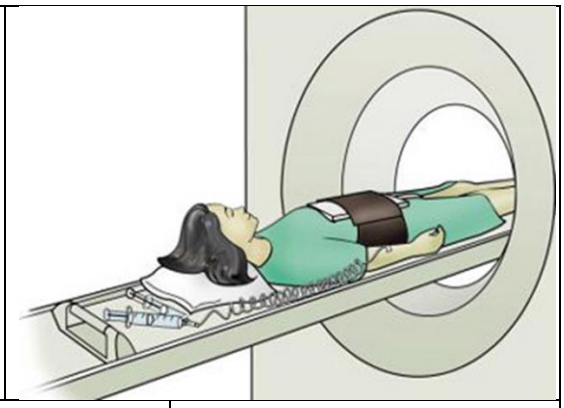
T2 => Uterus => 3 Layers:

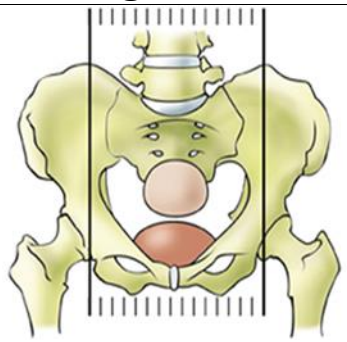
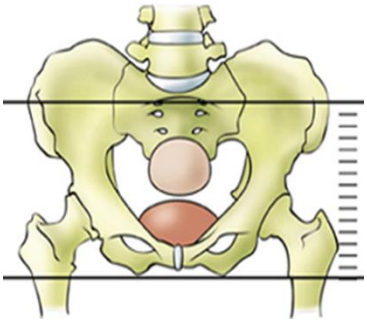
- **Endometrium:** Central high signal intensity; which represents the endometrium and its secretions.
- **Junctional zone:** low signal intensity junctional zone represents the inner portion of the myometrium and blends inferiorly with the fibromuscular stroma of the cervix.
- **The outer myometrium**: heterogeneous intermediate and high signal.

Sagittal T2	Axial Oblique T2
	

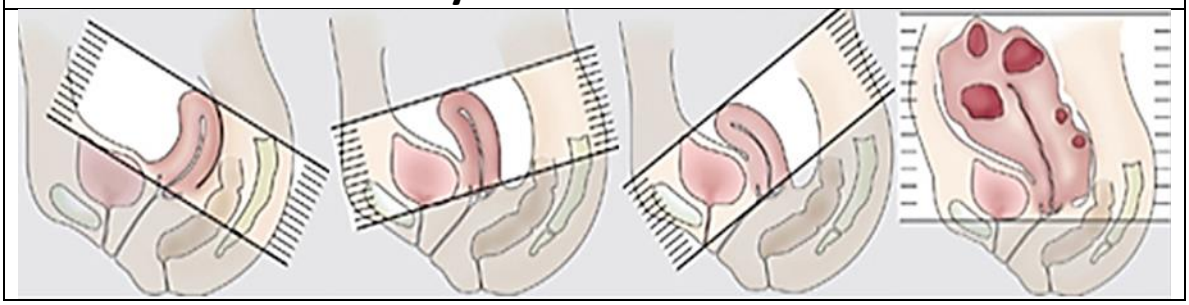
MRI Protocol

- The patient fast for 4–6 hours before the procedure.
- Intravenous line (20 or 22 gauge iv).
- Coil: Pelvic or torso array
- Patient Positioning: Supine, feet first
- Landmark: Just below top of iliac Crest



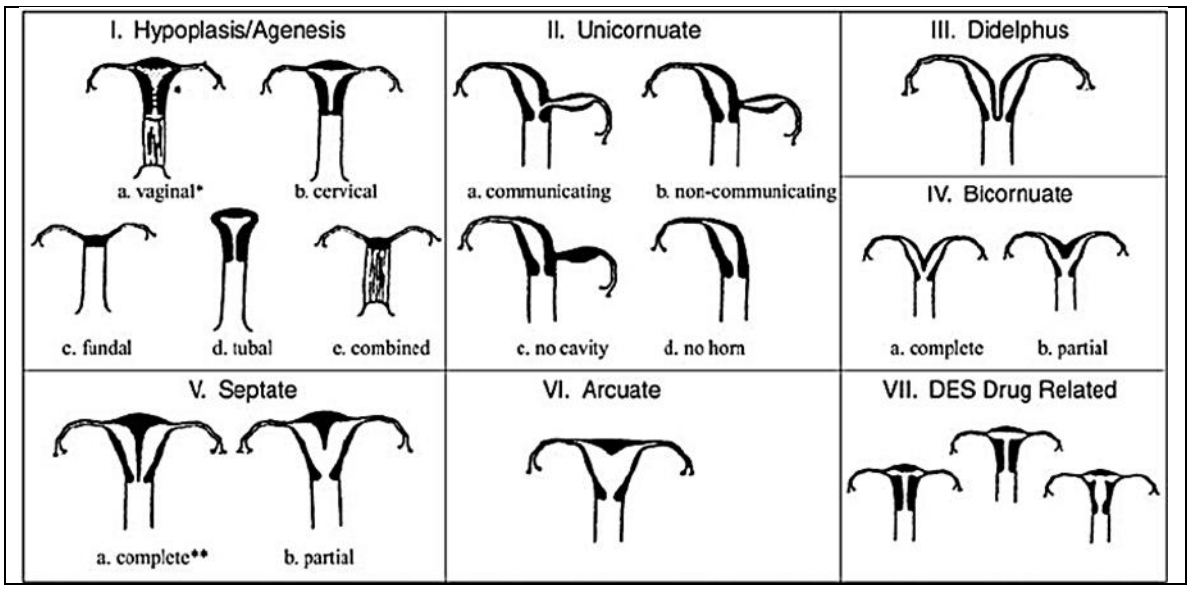
Sagittal T2	Axial T1	Coronal T2
		

Axial T2 Oblique: obtained in a plane perpendicular to the endometrial cavity



CLASSIFICATION OF FEMALE GENITAL TRACT MALFORMATIONS

I- The American Society of Reproductive Medicine (formerly American Fertility Society - [AFS]) Classification of Mullerian Duct Anomalies- 1998



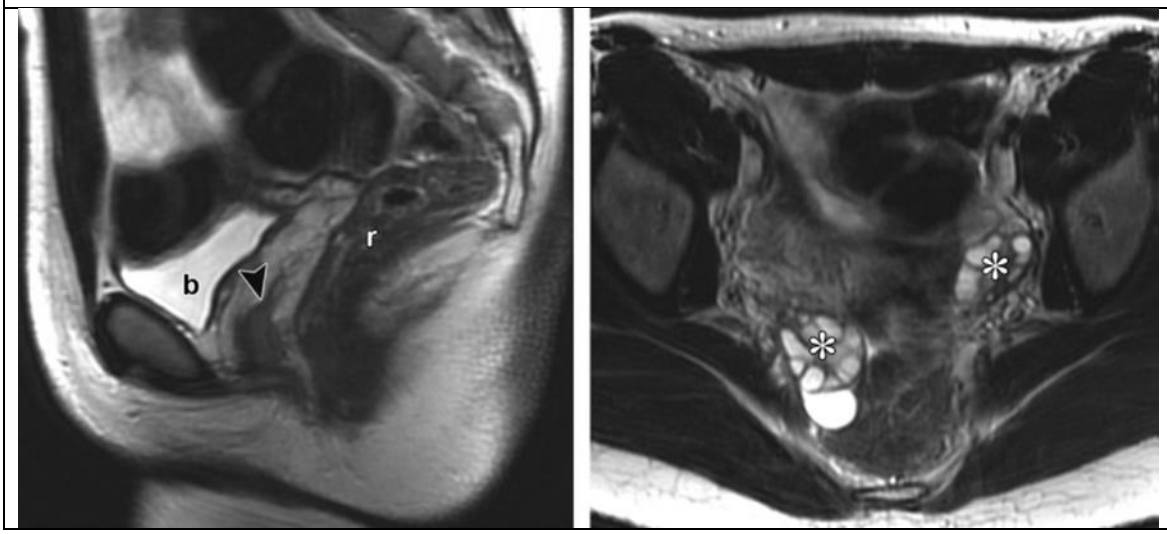
Class	Percentage	Description	Embryology	Clinical relevance	Prevalence
I	5-10%	Mullerian agenesis or hypoplasia	Failure of development	No reproductive potential	9.4% infertile population
II	10-20%	Unicornuate uterus	Complete/ near complete arrested development of Mullerian ducts (MDs.)	Surgery for II-A and II-B	6% infertile Women. 2.3% Recurrent miscarriages
III	5-20%	Uterus didelphys	Complete non-fusion of both Mullerian ducts.	May consider Metroplasty however Full term pregnancies have occurred.	2.9% infertile women 0.8% recurrent miscarriages.
IV		Bicornuate uterus	Partial non fusion of MDs.	Rarely need surgery.	10% infertile women 5.3% recurrent miscarriages
V	55%	Septate uterus	Failure of resorption of fibrous septum between two MDs.	Poorest obstetrical outcomes. Treatable with hysteroscopic resection of septum	46% infertile women 26.5% recurrent miscarriages
VI		Arcuate uterus	Near complete resorption of septum.	Usually none unless recurrent fetal loss	24% infertile women 65% recurrent miscarriage
VII		DES related uterine anomalies	In-utero exposure of DES (1945-70) increased risk of uterine malformations.	None	46% infertile women 26% recurrent miscarriage

Class I: Uterine Hypoplasia and Agenesis

- 5%–10% of müllerian duct anomalies
- Hypoplasia and agenesis of the uterus, cervix, fallopian tubes and proximal vagina.
- Result from failed or incomplete development of both müllerian ducts.
- The reproductive potential of patients with uterine hypoplasia is limited, and that of patients with uterine agenesis is absent.

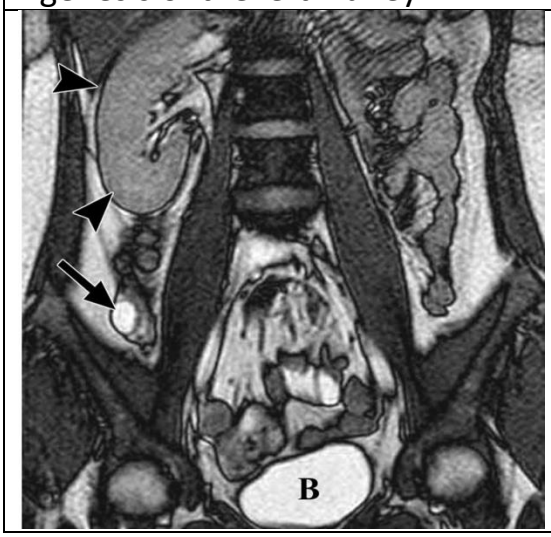
Class	Percentage of MDAs*	Description
I	5–10 %	Müllerian agenesis or hypoplasia
I-A		Vaginal agenesis or hypoplasia (uterus may be normal or may exhibit one or more of a variety of malformations)
I-B		Cervical agenesis or hypoplasia
I-C		Fundal agenesis or hypoplasia
I-D		Fallopian tube agenesis or hypoplasia
I-E		Combined agenesis or hypoplasia (two or more findings from classes I-A through I-D)

Absent Uterus + Cervix
Blind vaginal pouch
Normal Ovaries



Mayer-Rokitansky-Küster- Hauser (MRKH) Syndrome:

- The most common variant in this class of anomalies.
- Manifested by complete vaginal agenesis.
- 90% of patients presenting with associated cervical and uterine agenesis.
- 10% of cases, a rudimentary müllerian structure is identified. This structure can be either functional (endometrial layer present) or nonfunctional (endometrial layer absent).
- The atypical form of the syndrome includes associated abnormalities of the ovaries and fallopian tubes and renal anomalies.

Agenesis of the left kidney.	Anomalous pelvic location of kidney
	

Class II: Unicornuate Uterus

II	10–20 %	Unicornuate uterus
II-A		Rudimentary horn with an endometrial cavity that communicates with the (single-horned) uterus
II-B		Rudimentary horn with an endometrial cavity that does not communicate with the uterus
II-C		Rudimentary horn with no endometrial cavity
II-D		No rudimentary horn

- Result of failed or incomplete development of one of the müllerian ducts.

- In many cases, there is a rudimentary horn on the contralateral side:
  - with or without an endometrial cavity
  - may or may not communicate with the dominant horn.
- Rudimentary horns are usually best visualized with MRI, which also readily demonstrates the absence of an endometrium in the rudimentary horn
- Rudimentary horns with an endometrium are associated with an increased risk of endometriosis and a risk of pregnancy in the rudimentary horn

Imaging findings:

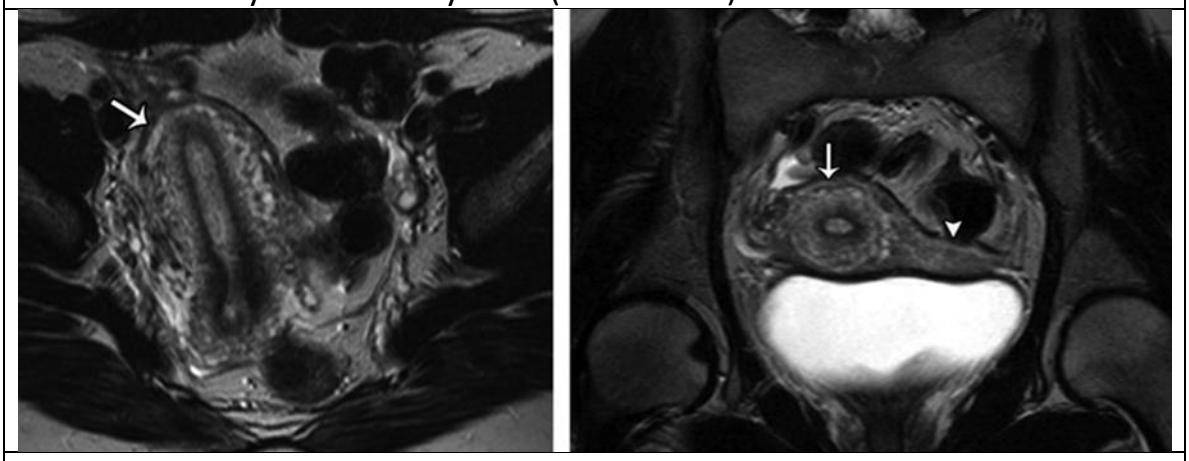
Unicornuate Uterus:

- Off-midline
- Banana-shaped / Bullet shaped uterine horn
- Normal endometrium + Myometrium
- Single fallopian tube.

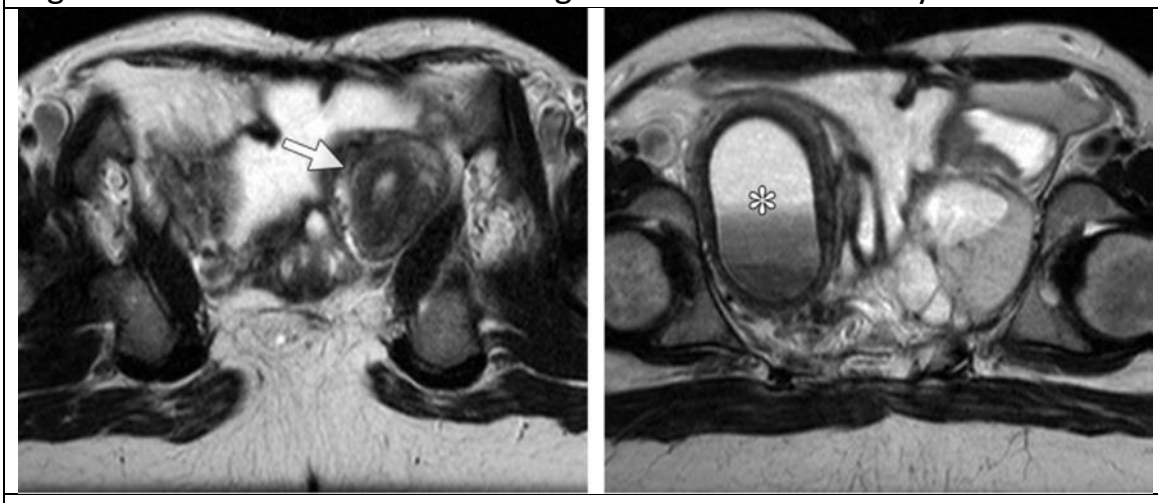
Rudimentary horn:

- Absent or present ?
- Functioning or not ?
- Communicating or obstructed ?
- If functioning + Obstructed => Endometrium => uterus distended with blood

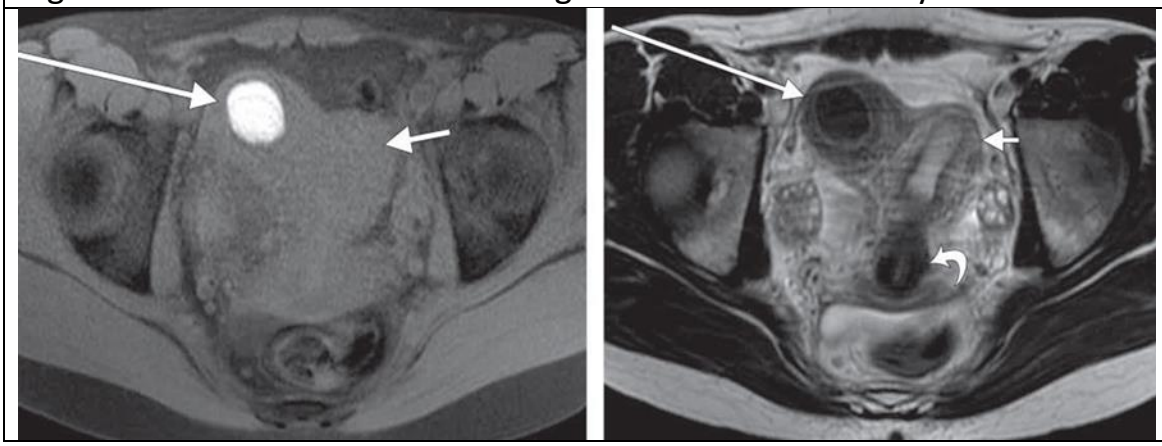
Right Unicornuate Uterus (arrow)
Left noncavitary rudimentary horn (arrowhead)



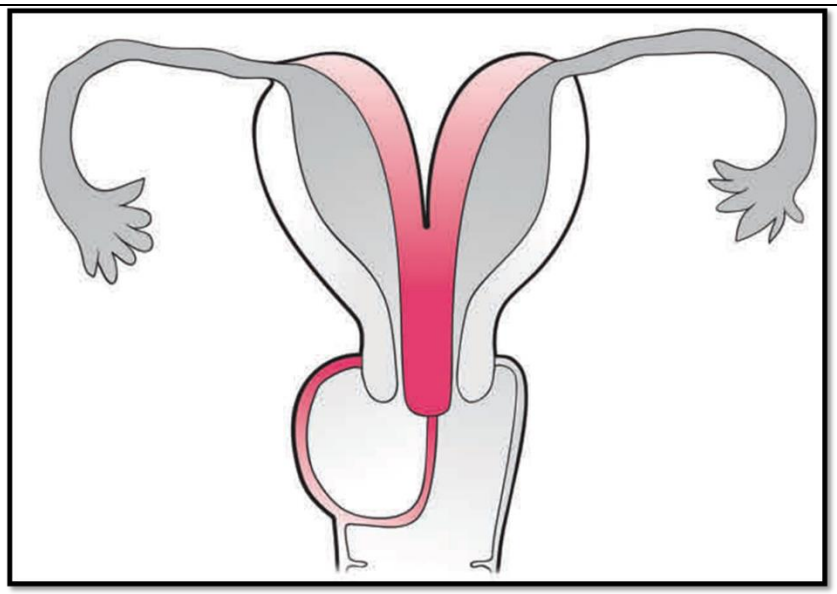
Left Unicornuate uterus
Right obstructed noncommunicating functional rudimentary horn



Left unicornuate uterus
Right obstructed noncommunicating functional rudimentary horn



Class III: Uterus Didelphys



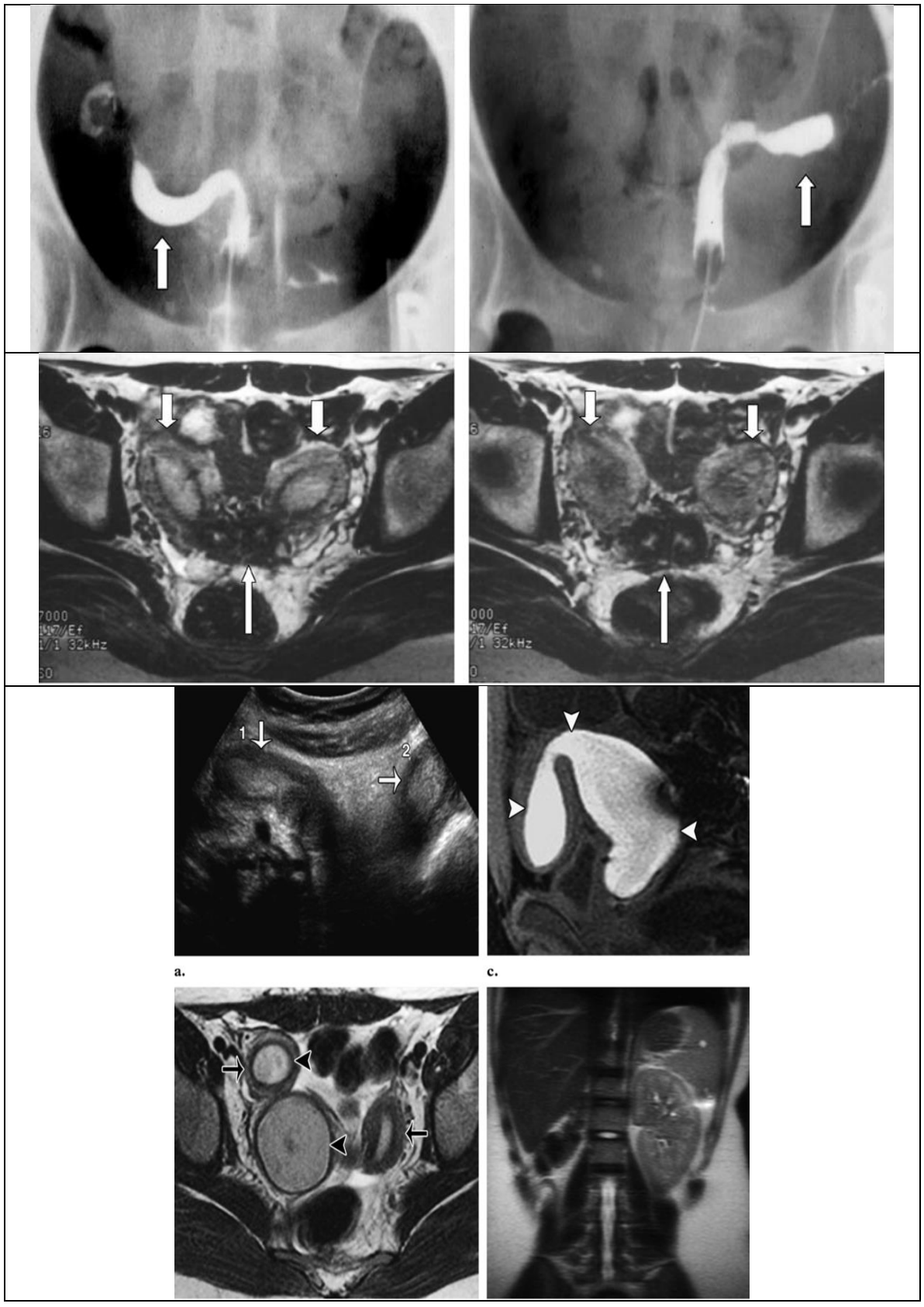
- Results from failed ductal fusion.
- 11% of müllerian duct anomalies.

Imaging findings:

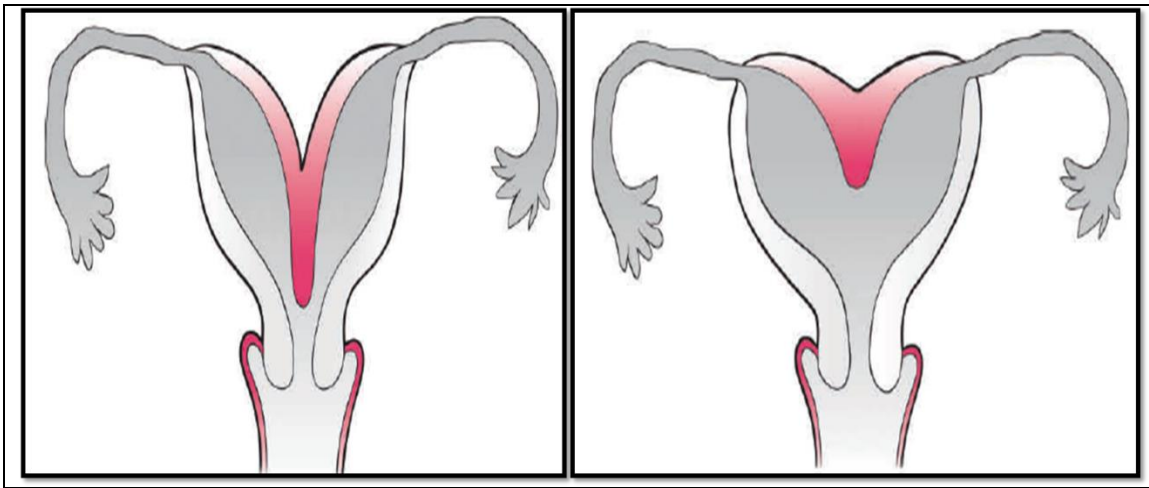
- 2 symmetric, widely divergent uterine horns
- A deep midline fundal cleft in the external contour of the uterus.
- 2 separate cervixes
- Longitudinal vaginal septum is present, 75% of cases
- ± unilateral horizontal hemivaginal septum and resultant unilateral hematometrocolpos

Wunderlich Syndrome

- Uterus didelphys
- Obstructed hemivagina is usually associated with ipsilateral renal agenesis.


1
2
a.
c.

Class IV: Bicornuate Uterus



IV	10 %	Bicornuate uterus
IV-A		Complete bicornuate uterus (septum extends to the internal or external os)
IV-B		Partial bicornuate uterus (septum is confined to the fundal region)

Incomplete fusion of the müllerian ducts results in a bicornuate uterus.

Bicornuate Unicollis Uterus:

- The septum extends to the internal os

Bicornuate Bicollis Uterus:

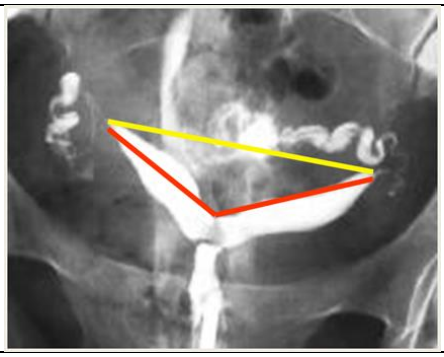
- The septum extends to the external os

Partial Bicornuate Uterus:

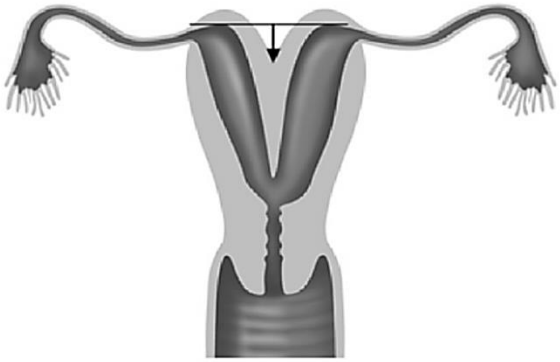
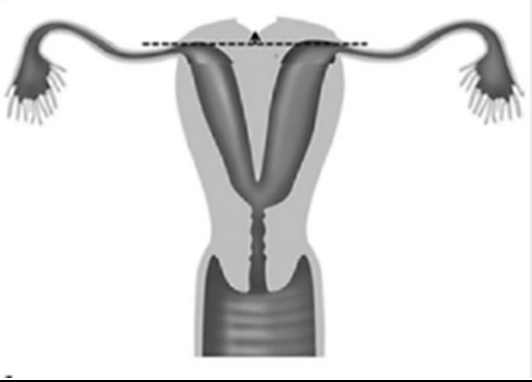
- The septum is confined to the fundal region.

HSG

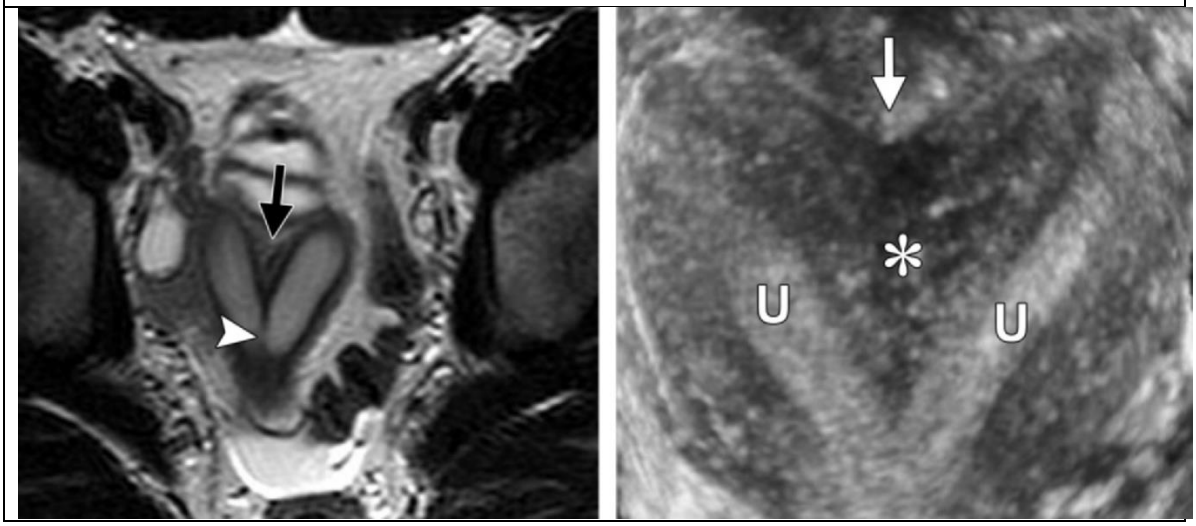
- 2 Symmetric divergent uterine horns.
- Widened intercorn distance >>4cm
- Widened Intercorn Angle >> 105
- Fundal cleft > 1cm



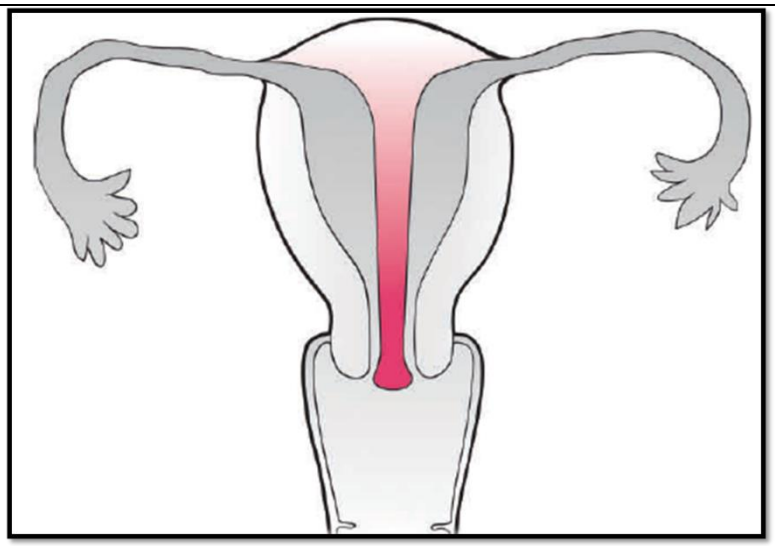
US/MRI Outer Fundal Contour

Fundal contour below line drawn between 2 tubal ostia	Fundal contour <5mm above line drawn between 2 tubal ostia
	

2 Uterine Cavities: Fundal Cleft >1cm



Class V: Septate Uterus



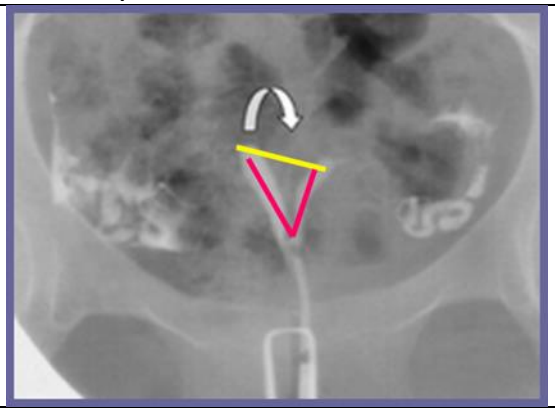
- Partial or incomplete septal resorption after müllerian duct fusion results in a septate uterus.
- It is the most common uterine anomaly.

V	55 %	Septate uterus
V-A		Complete septate uterus (septum extends to the internal os)
V-B		Partial septate uterus (septum does not reach the internal os)

HSG:

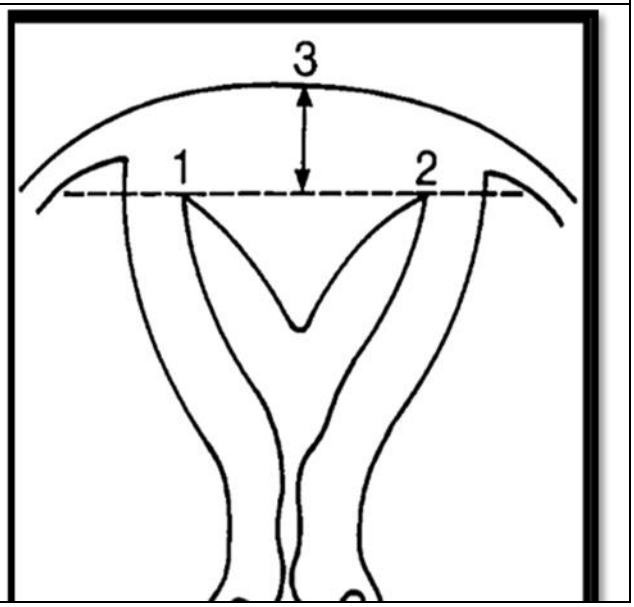
- 2 uterine cavities (Similar to a bicornuate uterus)
- cannot be used to evaluate the external uterine contour and
- does not allow reliable differentiation of septate from bicornuate uterus

- 2 Symmetric uterine horns.
- Intercorn distance < 4cm
- Intercorn Angle <<75

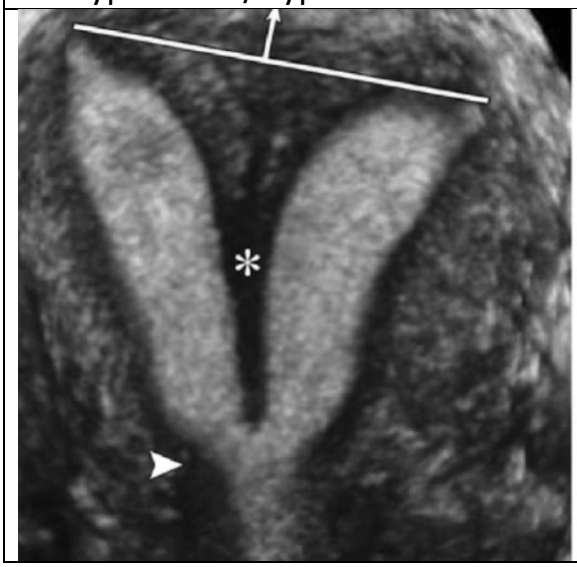


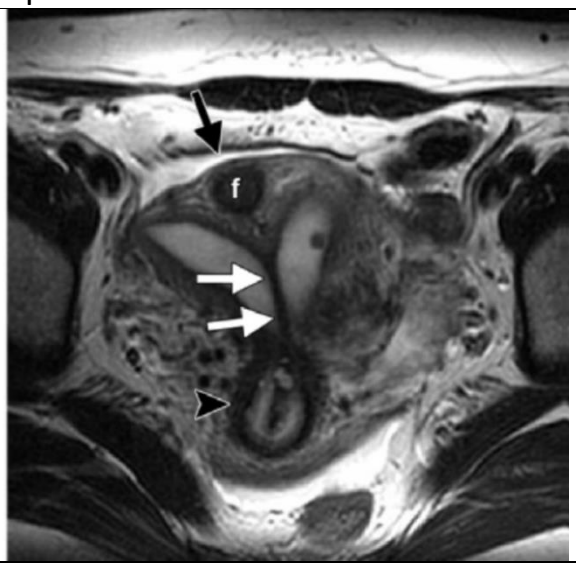
US/MRI Outer Fundal Contour

- Fundal external contour >5mm above line between tubal ostia

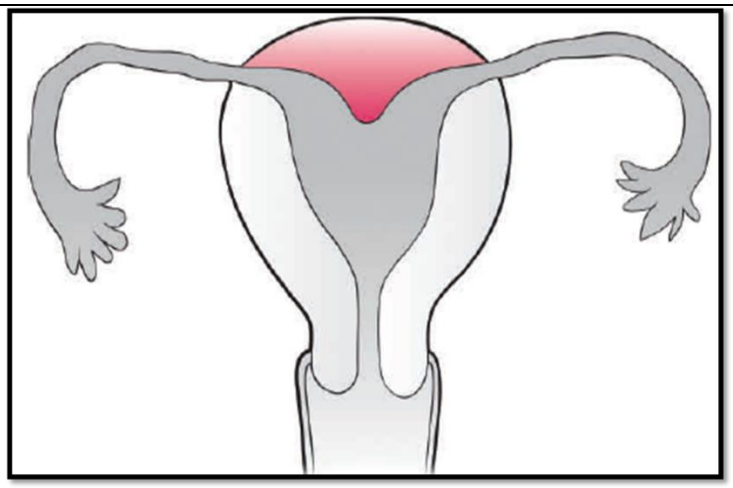


- 2 uterine Cavities
- Fundal Contour >5mm above line drawn between 2 tubal ostia
- Hypoechoic/Hypointense fibrous septum





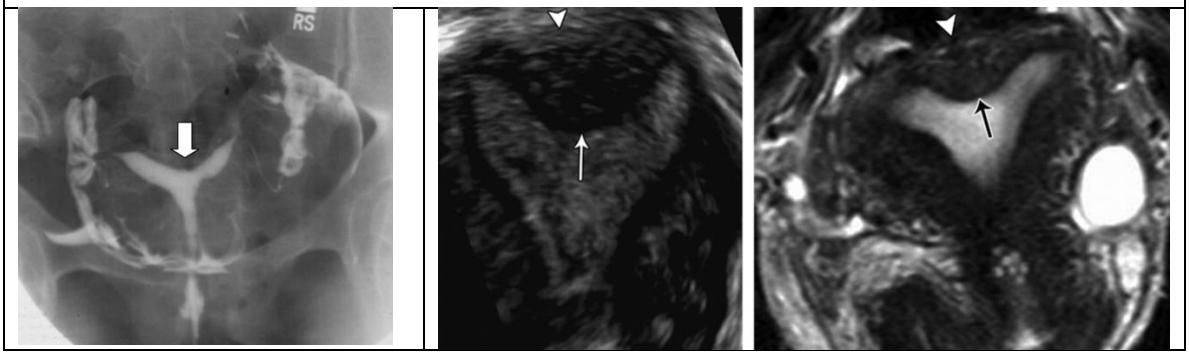
Class VI: Arcuate Uterus



- An arcuate uterus is the mildest anomaly and may be considered a normal variant.
- Result of near complete resorption of the uterovaginal septum
- An arcuate uterus usually has no effect on fertility or obstetric outcomes.

HSG, US, and MRI:

- A shallow, smooth, broad-based impression on the uterine cavity.
- Normal outer uterine contour.
- No division of the uterine horns

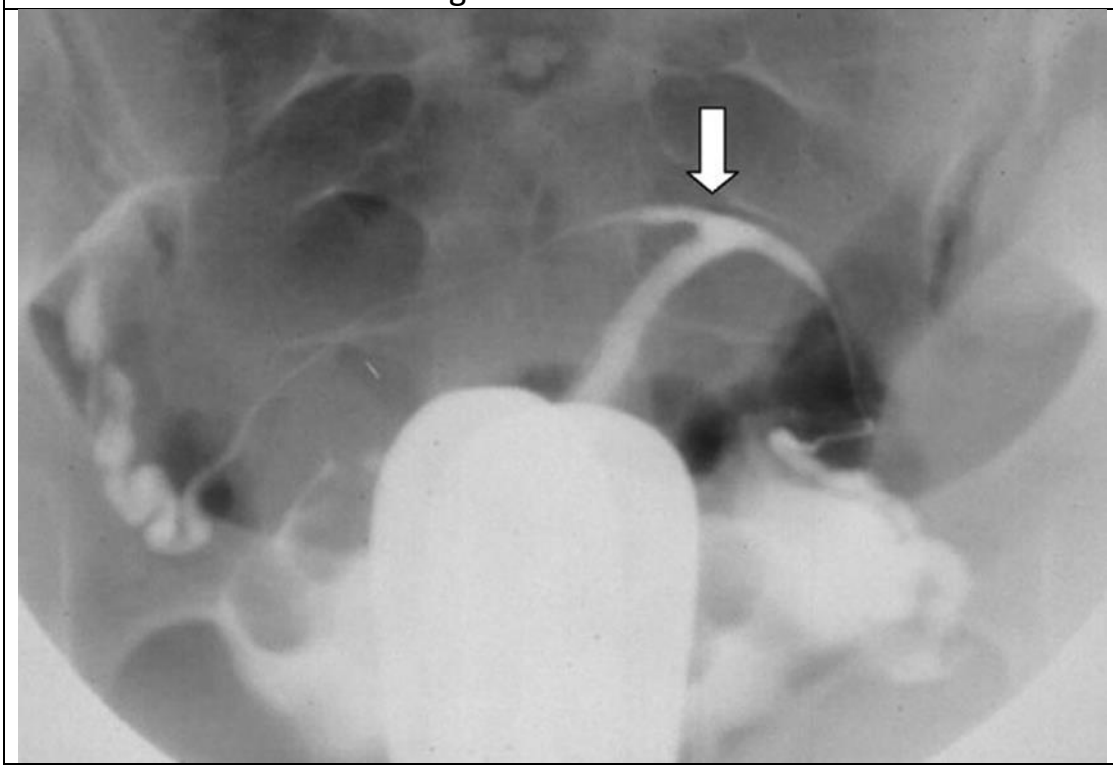


Class VII: DES-related Uterine Anomalies

- Between 1945 and 1970, DES was used for prevention of spontaneous abortions and treatment of hyperemesis gravidarum.

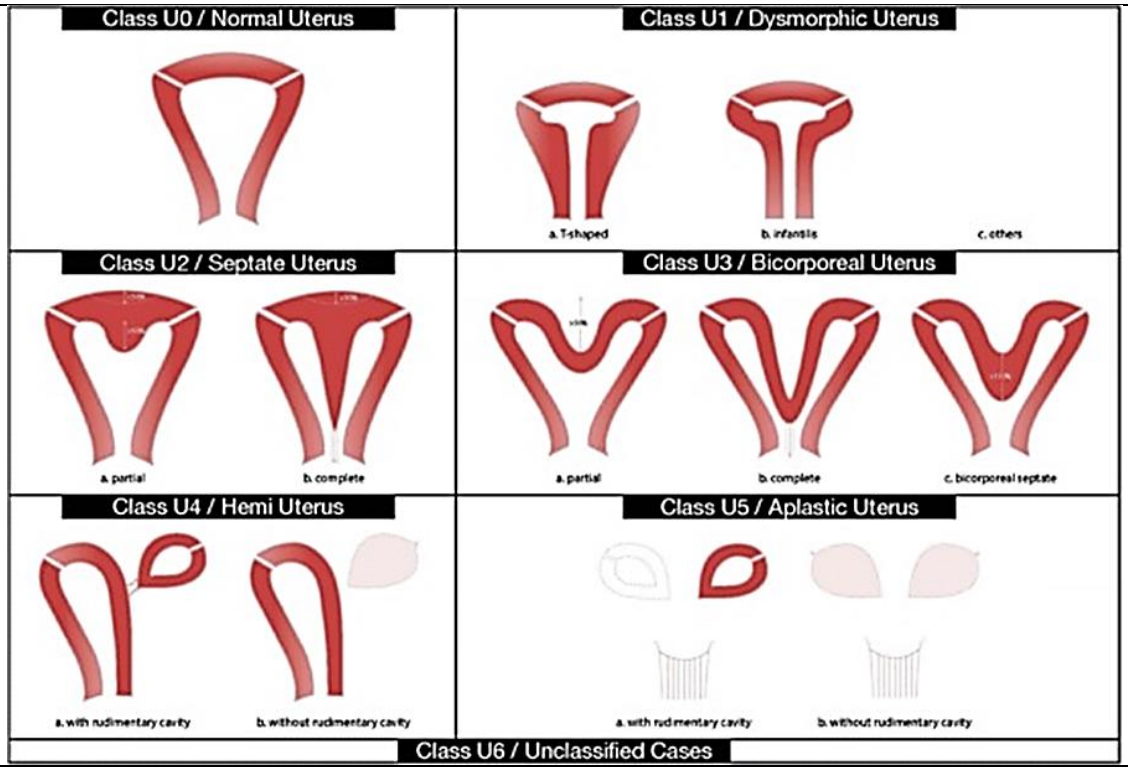
Female fetuses exposed to DES in utero are at risk for developing:

- Hypoplastic, irregular, **T-shaped uterus**
- Hypoplastic and strictured fallopian tubes,
- Increased incidence of vaginal clear cell carcinoma later in life.



European Society of Human Reproduction and Embryology and European Society for Gynaecological Endoscopy (ESHRE/ESGE) Classification Of Female Genital Tract Anomalies

	Uterine anomaly		Cervical/vaginal anomaly	
	Main class	*Sub-class*	*Co-existent class*	
U0	Normal uterus		*C0*	*Normal cervix*
U1	Dysmorphic uterus	a. T-shaped b. Infantilis c. Others	*C1*	*Septate cervix*
U2	Septate uterus	a. Partial b. Complete	*C2*	*Double 'normal' cervix*
U3	Bicorporeal uterus	a. Partial b. Complete c. Bicorporeal septate	*C3*	*Unilateral cervical aplasia*
U4	Hemi-uterus	a. With rudimentary cavity (communicating or not horn) b. Without rudimentary cavity (horn without cavity/no horn)	*C4*	*Cervical aplasia*
U5	Aplastic	a. With rudimentary cavity (bi- or unilateral horn) b. Without rudimentary cavity (bi- or unilateral uterine remnants/aplasia)	*V0*	*Normal vagina*
U6	Unclassified malformations		*V1*	*Longitudinal non-obstructing vaginal septum*
			V2	*Longitudinal obstructing vaginal septum*
			V3	*Transverse vaginal septum and/or imperforate hymen*
			V4	*Vaginal aplasia*



Endometrial Hyperplasia

- Endometrial hyperplasia refers to an increased proliferation of the endometrial glands relative to the stroma.
- One of the main concerns is the potential malignant transformation of the endometrial hyperplasia to the endometrial carcinoma.

Normal Endometrial thickness:

- ❖ Pre-menopausal < 20mm
- ❖ Post-menopausal on non HRT < 5mm
- ❖ Post-menopausal on HRT < 8mm
- ❖ Post-menopausal on Tamoxifen < 8mm

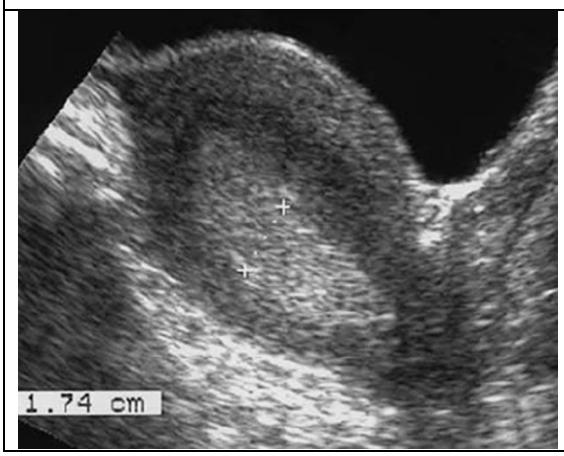
Pathological Subtypes:

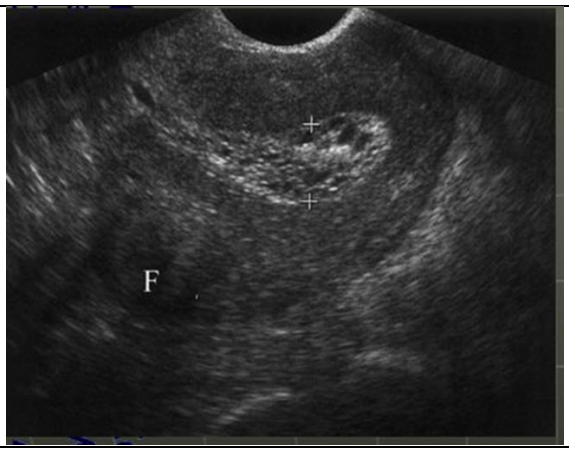
- Hyperplasia with atypia
- Hyperplasia without atypia

Associations

Unopposed oestrogen stimulation (either from an endogenous or exogenous source) is implicated in its pathogenesis; some of these conditions are:

- Obesity
- Polycystic ovary syndrome
- Pregnancy (and ectopic pregnancy)
- Oestrogen secreting ovarian tumours
- Granulosa cell tumour of the ovary
- Tamoxifen





Endometrial Polyp

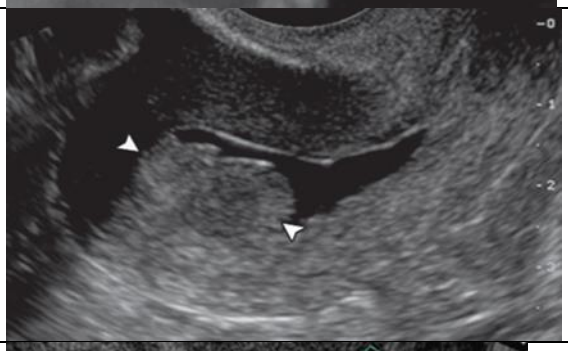
- Endometrial polyps are focal overgrowths of the endometrium.

HSG:

- Well defined filling defects and are best seen during the early filling stage.
- Small polyps may be obscured when contrast material completely fills the uterine cavity

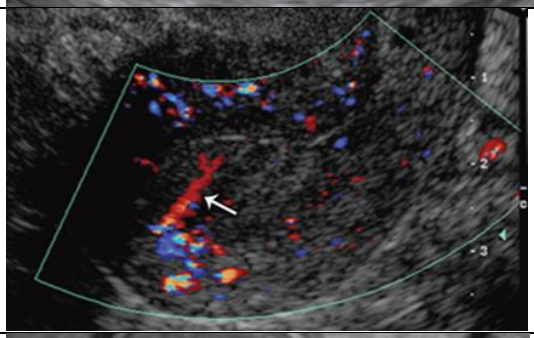
Sonohysterography:

- Endometrial polyps typically appear as echogenic intracavitary masses.
- A connection to the endometrium can sometimes be seen with pedunculated polyps.



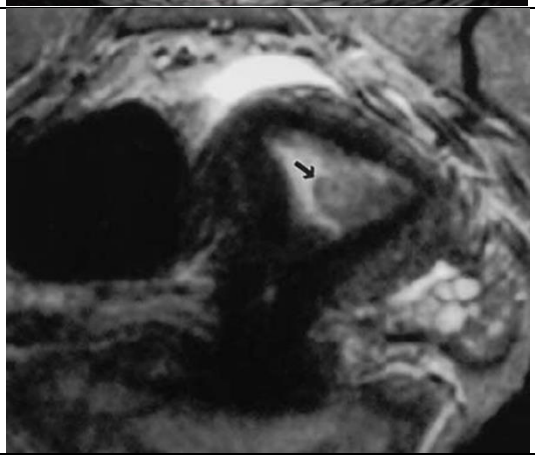
Color Doppler US

- Central feeding vessel of the polyp



MRI:

- T2 WI demonstrates a low SI lesion within the endometrial canal (arrow).



Adenomyosis

- Adenomyosis, a benign pathologic condition of the uterus, is characterized by the presence of ectopic endometrial glands within the myometrium, with surrounding smooth-muscle hyperplasia
- Age: 35 and 50 years
- Diffusely or may be focal lesion (adenomyoma).

- In women younger than 36 years, there is a strong association between adenomyosis and pelvic endometriosis, reported in approximately 90% of these patients.
- Adenomyosis may be associated with infertility due to impaired uterine contractility, which is necessary for directed sperm transport through the uterus

Pathophysiology:

- The pathogenesis of adenomyosis is poorly understood and is likely multifactorial.
- Proposed mechanisms include the lack of a basement membrane or the presence of a basement membrane defect at the endometrial-myometrial interface, which allows endometrial tissue to grow into the myometrium.
- Another theory postulates that endometrial migration may occur via lymphatic or vascular channels.

Role of Imaging:

- Establishment of the correct preoperative diagnosis is critical to avoid unnecessary intervention.
- MRI is a highly accurate noninvasive modality for diagnosis of adenomyosis.
- Differentiation of adenomyosis from other gynecologic disorders (leiomyoma), and planning of appropriate treatment.

TVUS

- ***Sensitivity = 53%–89% and specificity = 67%–98%.***

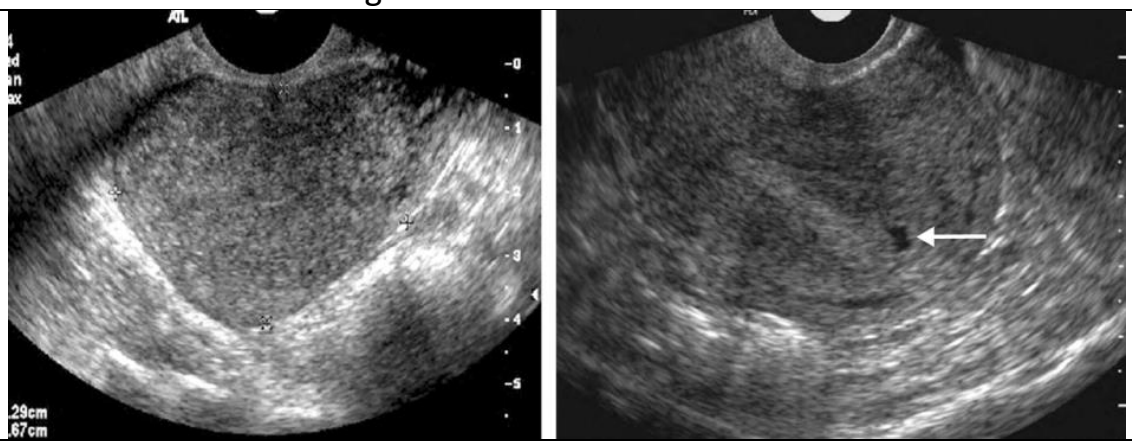
MR imaging

- ***Sensitivity = 78%–88% and specificity = 67%–93%***

A- Diffuse Adenomyosis

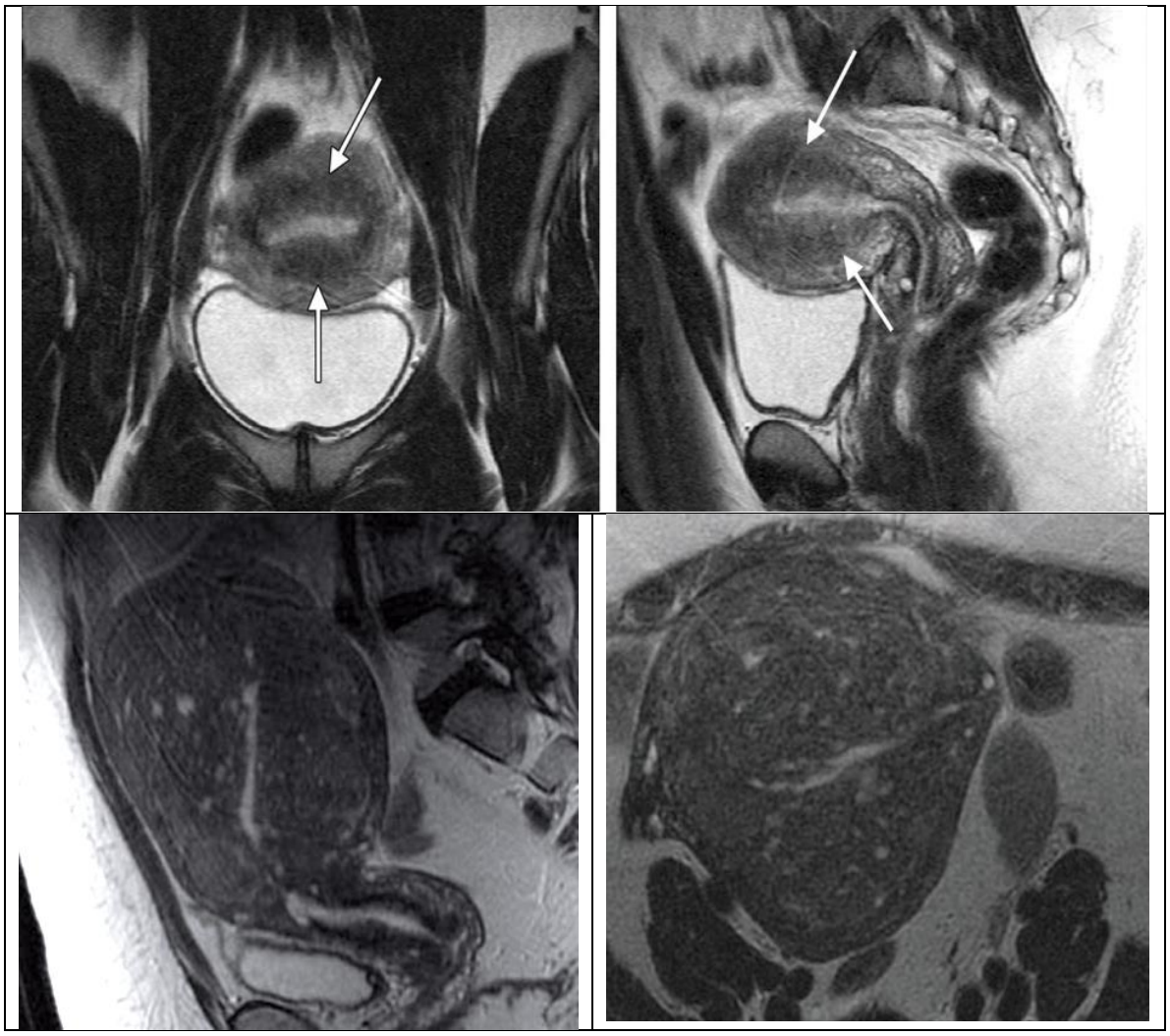
TVUS:

- Globular uterine enlargement
- Myometrial thickening
- Asymmetry of the anterior or posterior myometrial walls
- Heterogeneous myometrial echotexture: reflects the infiltrative process of islands of heterotropic endometrial tissue that are scattered diffusely throughout the myometrium and that are poorly demarcated from the surrounding myometrium
- Indistinct endometrial-myometrial interface
- Myometrial cysts: is highly specific for adenomyosis
- Subendometrial echogenic nodules or linear striations.



MRI:

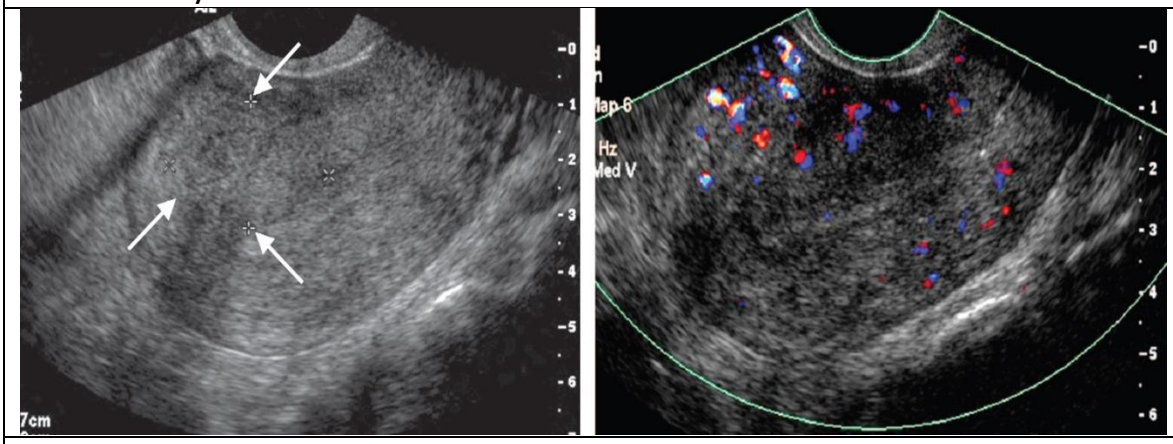
- Globular uterine enlargement
- Linear or nodular high T2 signal foci within the myometrium
- Diffuse thickening of the endometrial-myometrial junction (junctional zone) with low SI on T2 WI:
    - < 8 mm = Normal = Excludes the diagnosis of adenomyosis.
    - 8–12 mm = Suggestive = requires additional investigation.
    - ≥ 12 mm = Diagnostic of diffuse adenomyosis



B-Focal Adenomyosis (Adenomyoma)

TVUS:

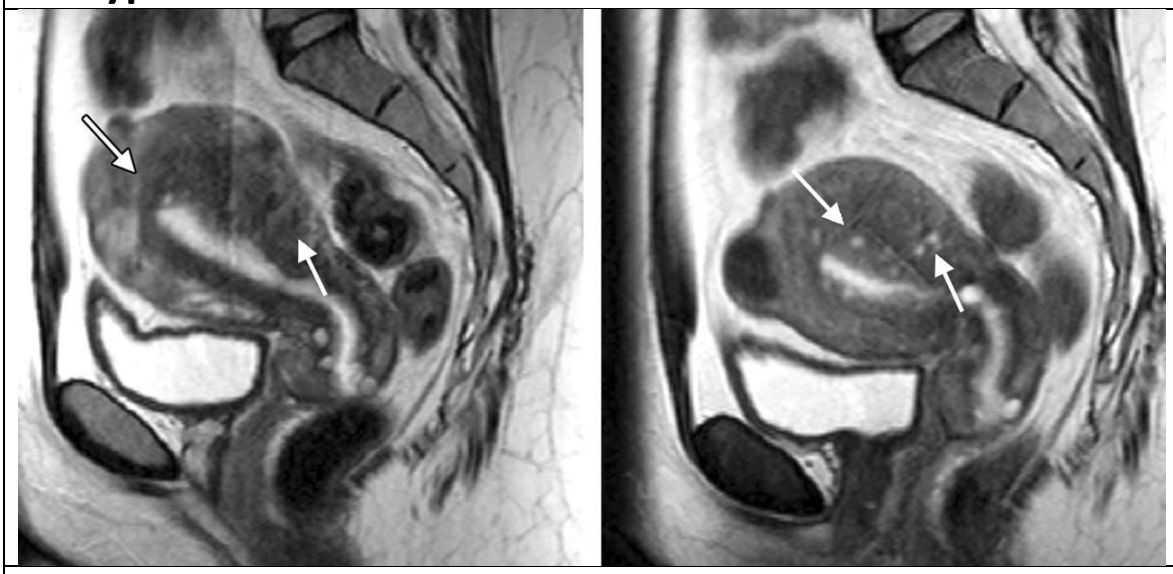
- An echogenic mass with ill-defined borders.
- These conglomerations of endometrial tissue are often difficult to recognize.
- Color and power Doppler US demonstrate the penetrating vascular pattern within the mass and facilitate making the diagnosis of focal adenomyoma



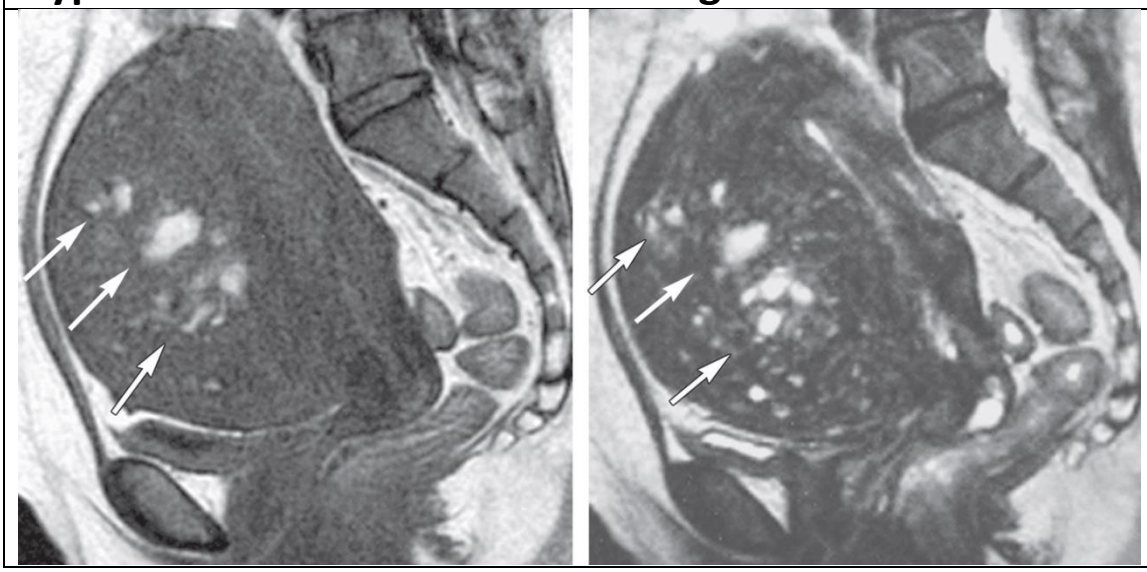
MRI:

- Ill-defined Myometrial mass with indistinct margins
    - Low SI on both T1 and T2 WIs correspond to smooth muscle hyperplasia.
- Focal thickening of the endometrial-myometrial junction (junctional zone) with low SI on T2 WI
- Linear or nodular foci within the myometrium of:
    - High SI on T2 WI corresponds to islands of ectopic endometrial tissue and cystic dilatation of glands.
    - High SI on T1 & T2 WI corresponds to menstrual hemorrhage occurs within these ectopic endometrial tissues.

Ill-defined myometrial mass Low signal T2 +
Widening of the junction zone +
T2 hyperintesne foci



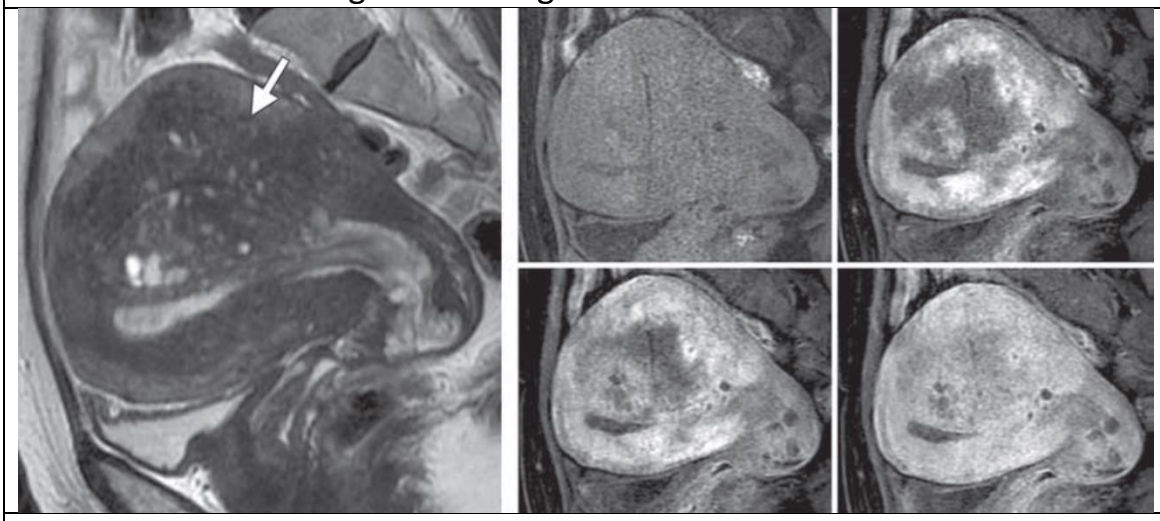
Hyperintense T1 and T2 hemorrhagic foci



❖Advanced MRI Imaging Modalities

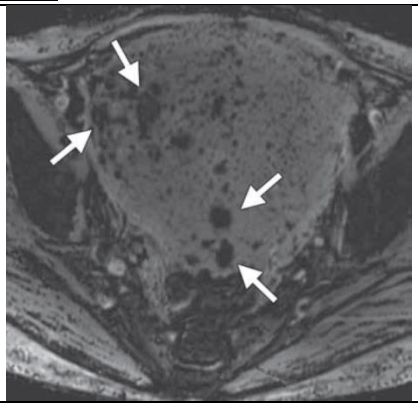
Dynamic MRI

- Gradual Heterogeneous Progressive contrast enhancement



Susceptibility Weighted Imaging

is sensitive for old hemorrhagic foci, which appear as spotty signal voids owing to the T2*-shortening effects of hemosiderin



DWI & ADC

Adenomyosis:

- DWI: Low – Intermediate signal
- ADC: high signal

Malignant lesions:

- DWI: high signal
- ADC: Low signal due to their high cellularity

	Fibroid	Adenomyoma
US	1) Hypoechoic masses 2) Well defined borders. 3) Vascularity only in the periphery of the mass (draping pattern).	1) The echogenicity of the mass is increased compared with the surrounding myometrium. 2) Poorly defined 3) Vascularity inside the mass (penetrating pattern).
MRI	4) Well-defined mass 5) Separate from the junctional zone 6) Low signal on T1 &T2	4) Poorly marginated 5) Continuous with the JZ 6) Focal thickening of the junctional zone > 12 mm.

Leiomyoma

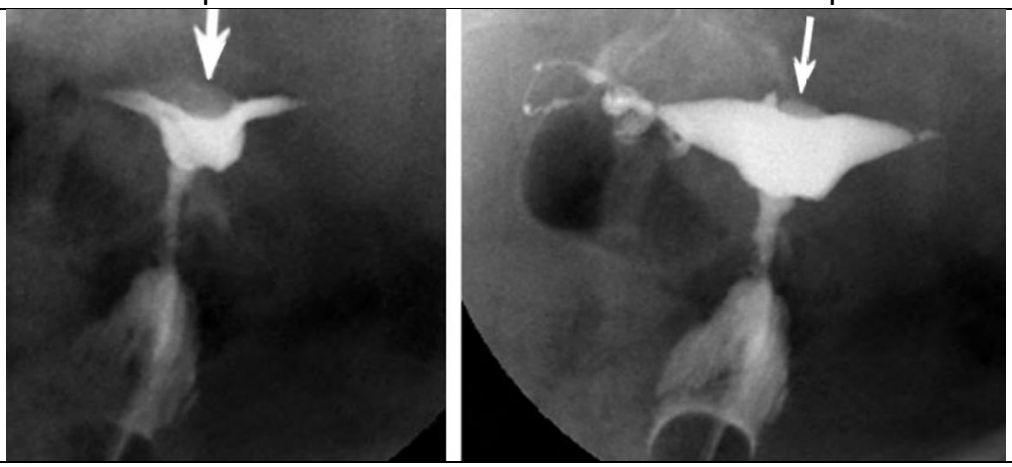
- The most common benign pelvic mass lesions
- The most common cause of uterine enlargement in non-pregnant women.
- They most often occur in multiples but also may occur singly.
- Infertility may result when leiomyomas are numerous or have submucosal or intracavitary locations that interfere with embryo transfer and implantation.

Location:

- Submucosal = directly underneath the endometrial mucosa
- Intramural = within the myometrial wall
- Subserosal = directly underneath the outer uterine serosa

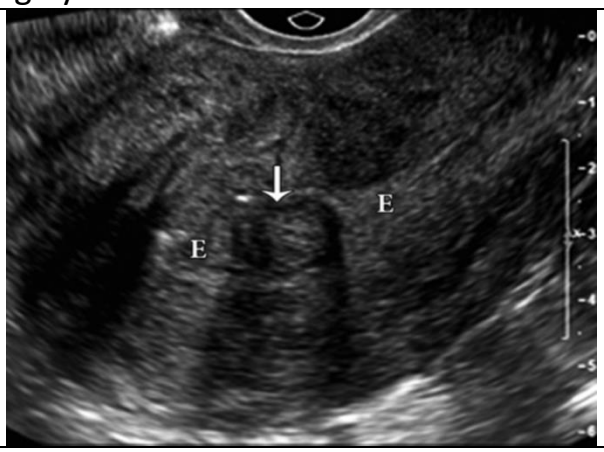
HSG:

- Large myomas cause uterine enlargement and distortion of the shape of the endometrial cavity.
- Only submucosal myomas are depicted at HSG as a well defined filling defect of the uterine cavity can best be seen during early contrast material filling of the uterus but may be obscured when the uterus is completely opacified.
- If the lesion is located near the uterine cornua, it may obstruct the ipsilateral fallopian tube and thus cause a lack of tubal opacification.



US:

- The uterus may be enlarged or lobulated
- Uniformly hypoechoic or have heterogeneous echogenicity
- Hyperechoic calcifications and they may be accompanied by an acoustic shadow.
- They may be largely submucosal and distort the endometrium.



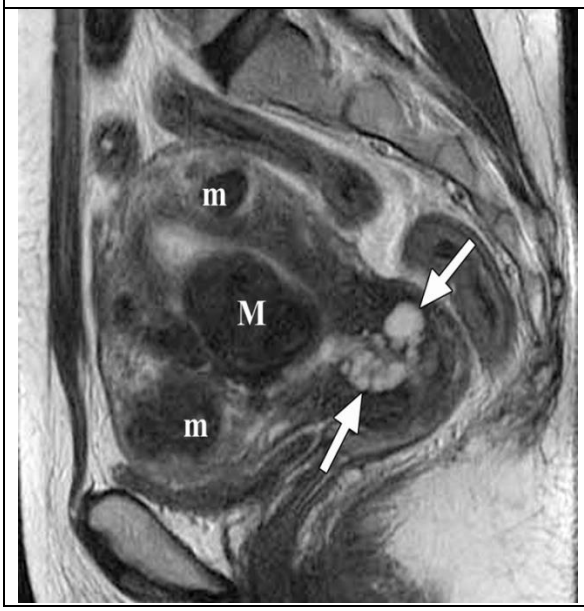
MRI:

- The myomatous uterus often appears enlarged and lobulated.
- At MR imaging, leiomyomas can demonstrate various signal intensities depending on the type of degeneration:

1) **Hyaline degeneration** is the most common type:
    - Low signal intensity on T2
    - No enhancement
2) **Edema** shows high SI on T2 WI with marked enhancement.
3) **Cystic degeneration:**
    - Rounded cystic areas
    - Low SI on T1 WI
    - High SI on T2 WI
    - NO enhancement
4) **Myxoid degeneration:**
    - Cystic mass filled with gelatinous material
    - Low signal on T1
    - High SI on T2 WI
    - Delayed enhancement.
5) **Red degeneration:** is a kind of hemorrhagic infarction;
    - Peripheral rim of high SI on T1 WI
    - Low SI on T2 WI
    - NO enhancement

Multiple well defined myometrial lesions
T2 low signal intensity
+C: Weak enhancement

Multiple well defined fibroids. M= Submucosal fibroid M= Intramural fibroid	Large submucosal fibroid



Intrauterine Devices (IUDS)

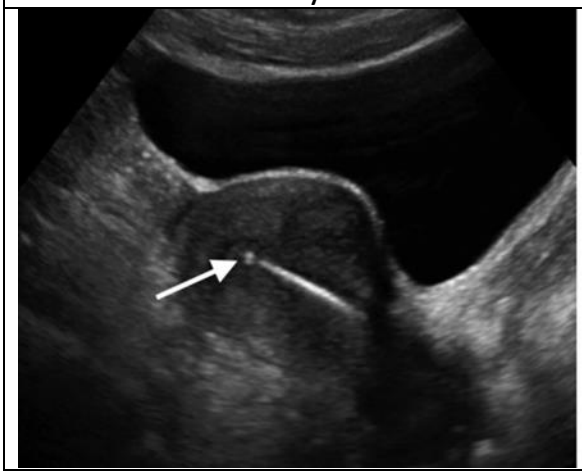
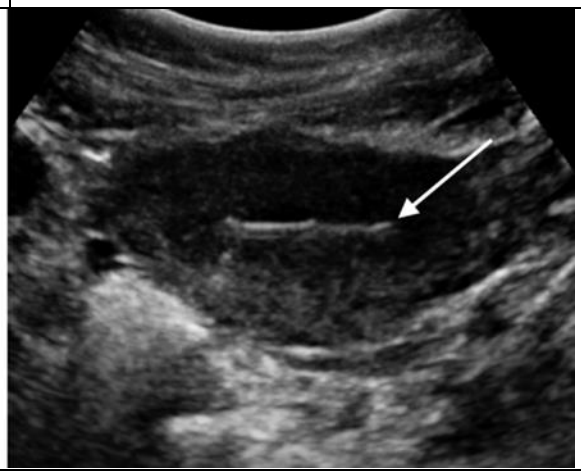
- Commonly used, highly effective, and rapidly reversible form of contraception.
- IUD consists of a:-
    - T-shaped polyethylene frame with a copper wire or a levonorgestrel-containing collar around the stem.
- Overall, IUDs are 98%–99% effective in preventing pregnancy
- The copper IUD works for up to 10 years,
- The levonorgestrel-releasing IUD works for up to 5 years

<u>The contraceptive effects of IUDs are multifactorial.</u>

- IUDs produce chronic inflammatory changes of the endometrium and fallopian tubes that have spermicidal effects,
- inhibit fertilization,
- Create an inhospitable environment for implantation.
- The levonorgestrel-releasing IUD also alters and partially inhibits ovulation

❖US Appearance Of Normal Placed IUD:

- The stem of a properly placed IUD is straight is entirely within the endometrial cavity,
- The arms of the IUD extending laterally at the uterine fundus
- The distance from the top of the uterine cavity to the IUD = 3 mm
- A distance >4 mm is more often associated with symptoms such as bleeding and pain with a higher risk of expulsion or displacement

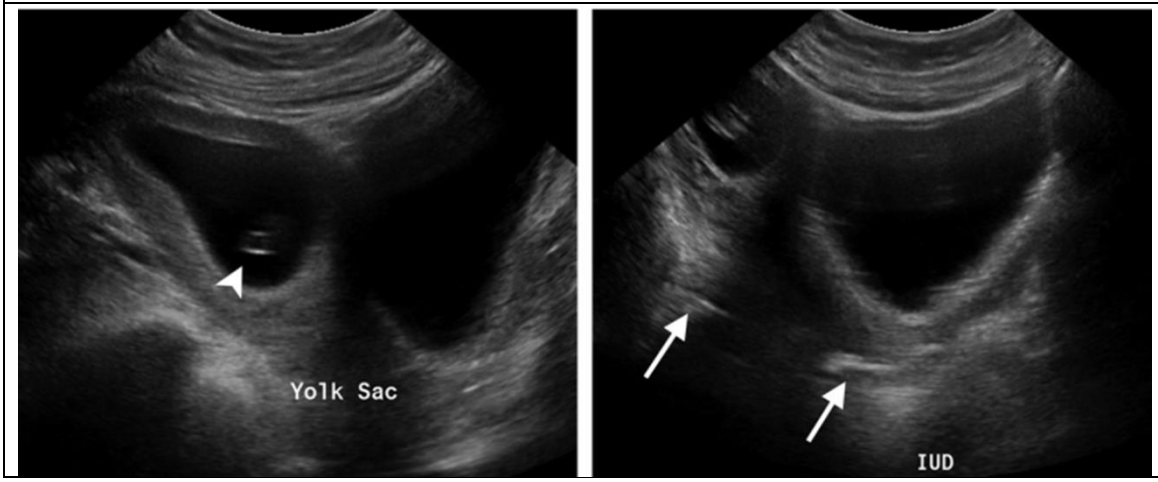
Longitudinal US	Transverse US
IUD stem entirely within the endometrial cavity Its proximal end (arrow) at the top of the uterine cavity.	IUD arms (arrow) extend laterally at the uterine fundus
	

❖ IUD Complications:

1) IUD Expulsion

- Relatively common up to 10% of patients.
- Risk factors:-
  - Insertion early in the menstrual cycle
  - Nulliparity
  - Menorrhagia
  - Immediate postpartum insertion
  - Patients with severe anatomic distortion of the uterine cavity (eg, a bicornate uterus or large submucosal fibroids)
- IUD in a cervical location is associated with increased accidental pregnancy compared with a properly positioned IUD

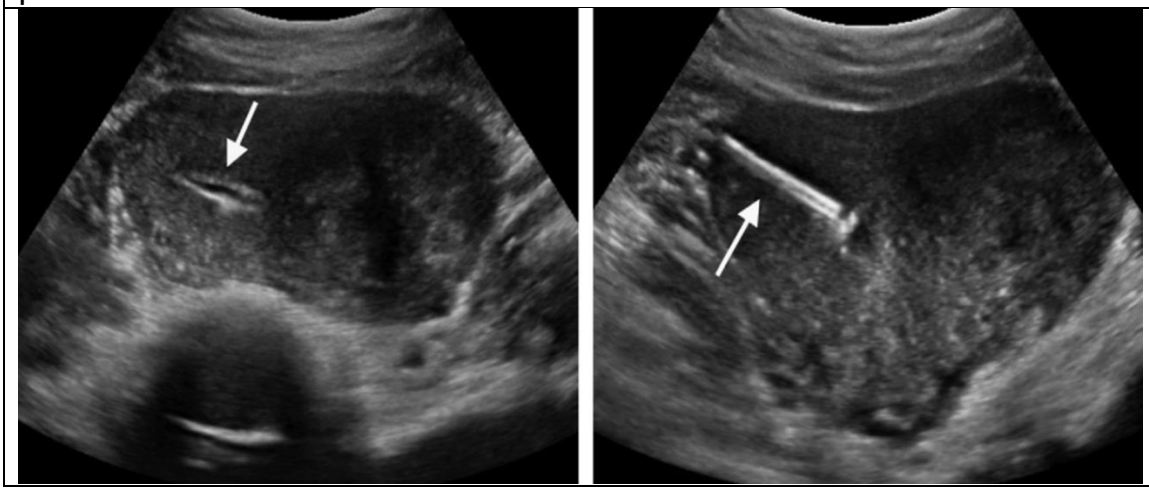
Intrauterine pregnancy + Expulsion of IUD



2) Displaced IUD

- Commonly encountered problem in up to 25%
- Usually asymptomatic, although some affected patients present with cramping or bleeding.
- No guidelines exist for management in asymptomatic patients with a displaced IUD.
- The greater the displacement of the IUD, the less effective it is for contraception and the more likely it is to be expelled.
- Removal of a displaced IUD without myometrial perforation is generally uncomplicated, being performed in the clinical setting with alligator forceps or an IUD hook. Rarely, hysteroscopic removal is necessary.

Malpositioned IUD (arrow) in the right uterine fundus + No myometrial perforation



3) Embedment

- IUD penetration into the endometrium or myometrium without extension through the serosa
- occur to some degree in up to 18%
- more common in females with smaller fundal endometrial diameters

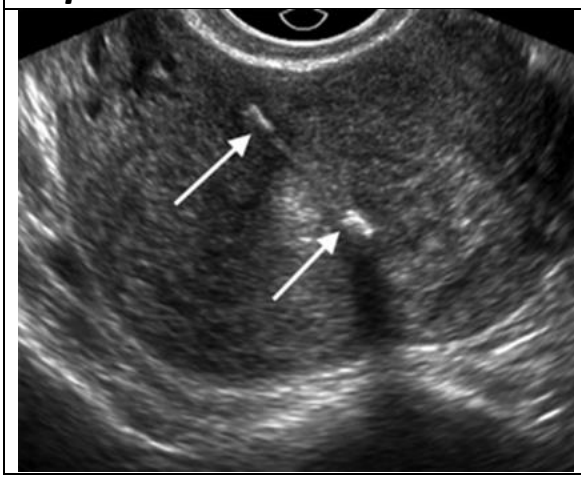
US

- examination of choice for initial imaging
- 3D US in particular has been shown to be helpful in identifying malpositioned and embedded IUDs in symptomatic patients

CT

- In the emergent setting,
- commonly performed to exclude other causes for the patient's symptoms and to verify US findings
- Should not be the initial imaging study in patients with suspected IUD embedment.

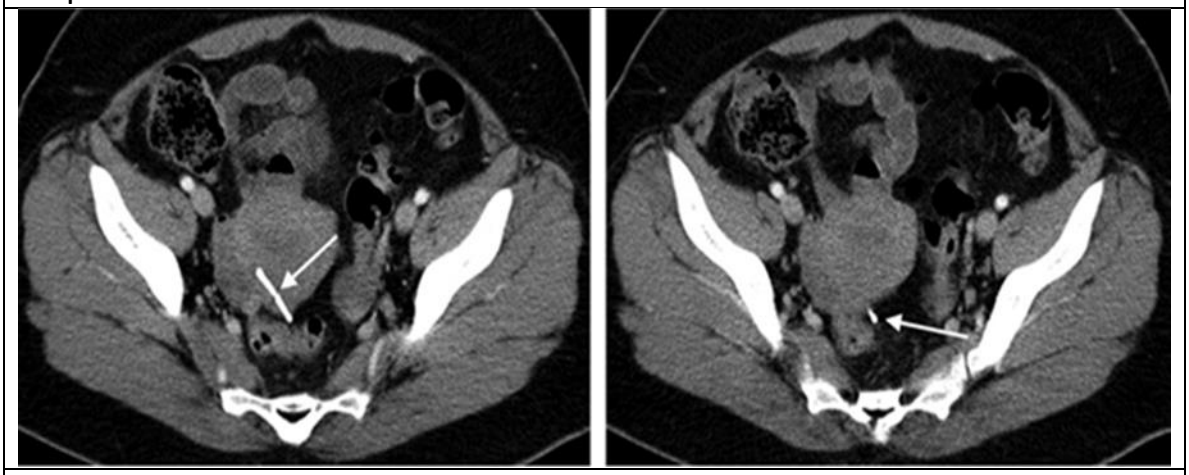
- ***The base of the stem (arrowhead) is embedded in the posterior cervix.***



4) Complete Perforation

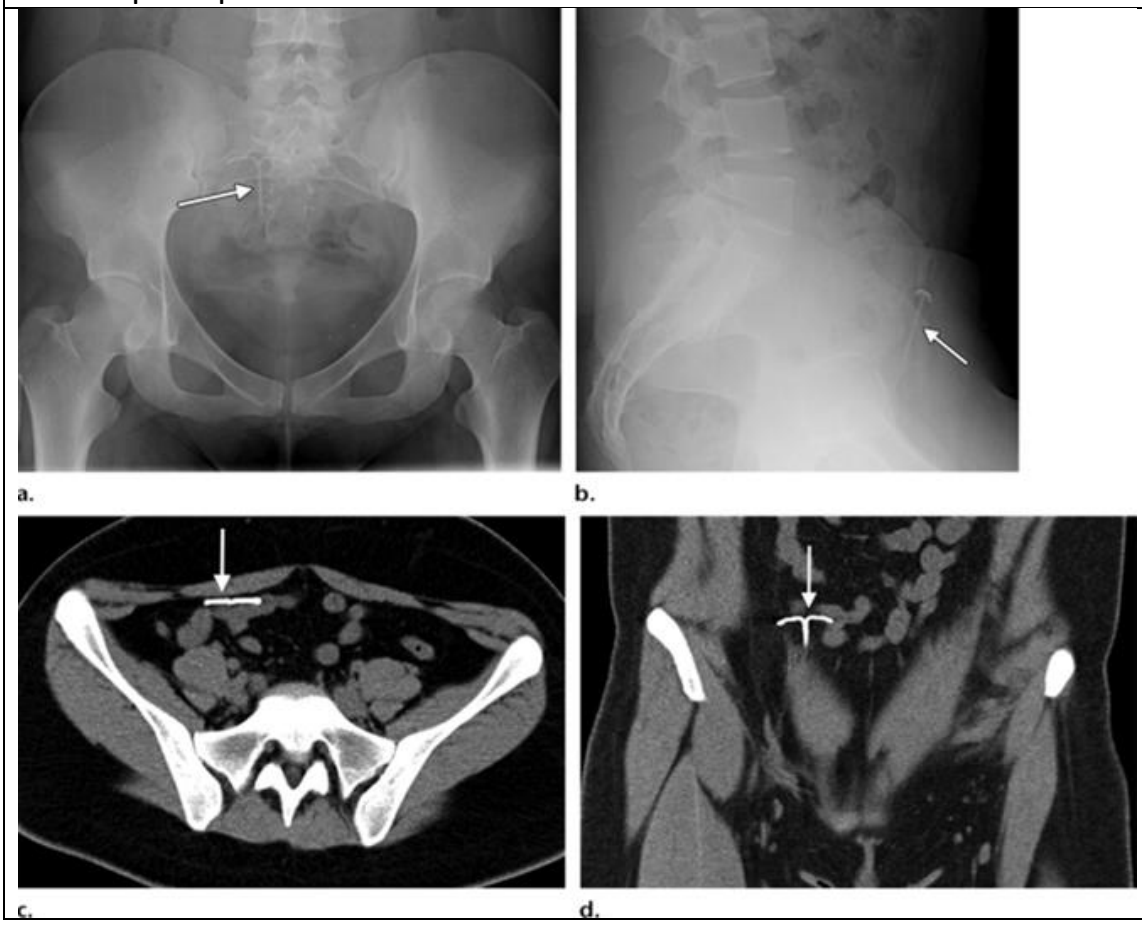
- ***Complete Perforation =*** IUD has perforated through all three layers of the uterus and is completely within the peritoneal cavity.
- ***Partial Perforation =*** IUD extends through the uterine serosa but is still partially contained in the uterus
- Pelvic US initial imaging study followed with abdominopelvic radiography.

- Omental adhesions is the most common complication or adherent to bowel or omentum
- Adhesion formation => Infertility, chronic pain, and intestinal obstruction.
- Perforate adjacent structures => peritonitis, fistulas, or hemorrhage
- Intraabdominal infection or abscess formation occurs in up to 16% of patients

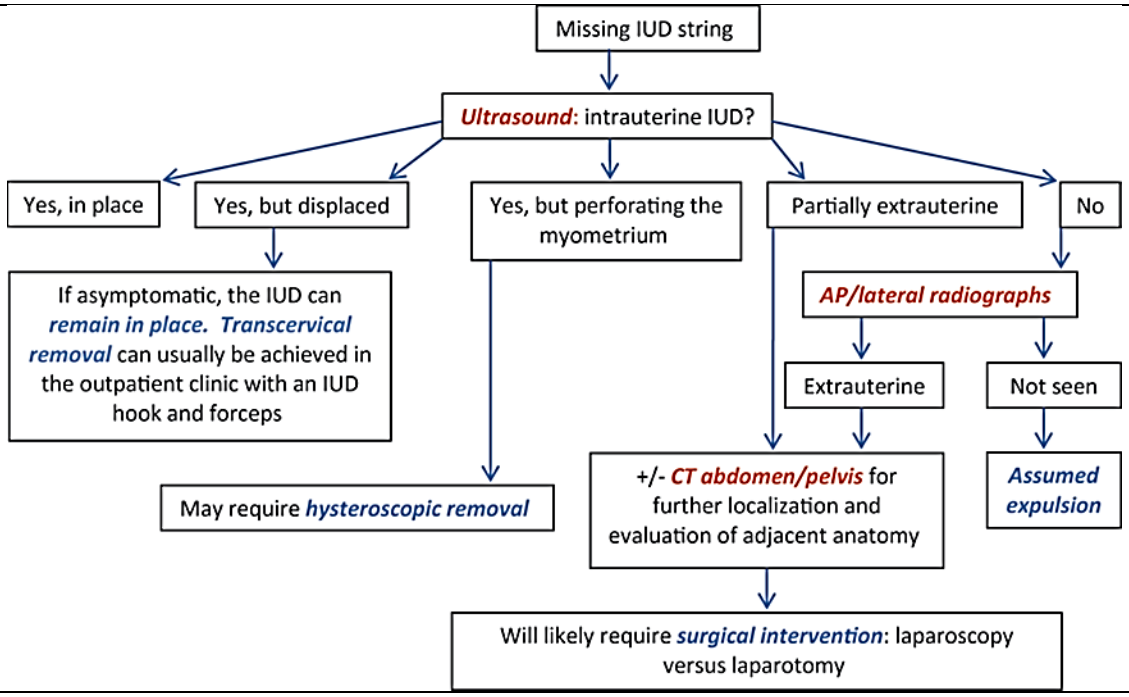


Abdominopelvic Radiography:

- Required for the diagnosis of expulsion
- Also be helpful for determining whether there is complete uterine perforation.
- IUD is located above the pelvic brim, is diagnostic
- Rotation of the IUD of 90° or 180° at is a less specific indication of complete perforation.



❖ Imaging Algorithm


Missing IUD string
Ultrasound: intrauterine IUD?
Yes, in place
Yes, but displaced
Yes, but perforating the myometrium
Partially extrauterine
No
If asymptomatic, the IUD can remain in place. Transcervical removal can usually be achieved in the outpatient clinic with an IUD hook and forceps
AP/lateral radiographs
Extrauterine
Not seen
May require hysteroscopic removal
+/- CT abdomen/pelvis for further localization and evaluation of adjacent anatomy
Assumed expulsion
Will likely require surgical intervention: laparoscopy versus laparotomy

Endometrial Cancer

- 4th most common malignancy in females
- 1st common malignancy of the female reproductive tract.

Age:

- Postmenopausal women, peaking in the decade 55–65 years.

Risk factors:

- Hereditary nonpolyposis colorectal cancer (HNPCC) gene who usually develop endometrial cancer before the age of 50 years.
- Long-term treatment with Tamoxifen for breast cancer.
- Chronic exposure to unopposed oestrogens, either extrinsic or as a result of obesity or ovarian malfunction, for example in polycystic ovarian disease.
- There is also an association between endometrial cancer and diabetes mellitus.

Histopathology:

The majority (75%):

- ***Adenocarcinoma of endometrioid type***

The less common:

- Papillary serous
- Adenosquamous
- Clear cell.

Rare tumours of stromal origin include:

- Endometrial sarcoma
- Mixed Müllerian tumour
- Leiomyosarcoma.

Prognosis depends on:

- Stage
- Depth of myometrial invasion
- Lymphovascular invasion
- Histologic grade
- Nodal status.

❖ Staging Of Endometrial Cancer

2009 FIGO Staging System for Endometrial Cancer

Stage	Description
IA	Tumor confined to uterus, <50% myometrial invasion
IB	Tumor confined to uterus, ≥50% myometrial invasion
II	Cervical stromal invasion
IIIA	Tumor invasion into serosa or adnexa
IIIB	Vaginal or parametrial involvement
IIIC1	Pelvic node involvement
IIIC2	Paraaortic node involvement
IVA	Tumor invasion into bladder or bowel mucosa
IVB	Distant metastases (including abdominal metastases) or inguinal lymph node involvement

❖Tumor T2 Signal:

Relation of Tumor to Endometrium:

- Tumor heterogeneous intermediate signal intensity relative to high signal intensity of normal endometrium or intracavitary fluid, and the low signal of myometrium

Relation of Tumor to Myometrium:

- Myometrial invasion is indicated by replacement of the relatively hypointense myometrium by intermediate signal of tumor contiguous with the primary tumor.

Relation of Tumor to Cervix:

- Cervical invasion is indicated by replacement of the low signal of the cervical stroma by intermediate signal of tumor contiguous with the primary tumor.

❖Dynamic Contrast-enhanced MRI:

Relation of Tumor to Endometrium:

- Endometrial tumors enhance earlier than does normal endometrium, which aids in the detection of small tumors confined to the endometrial complex.

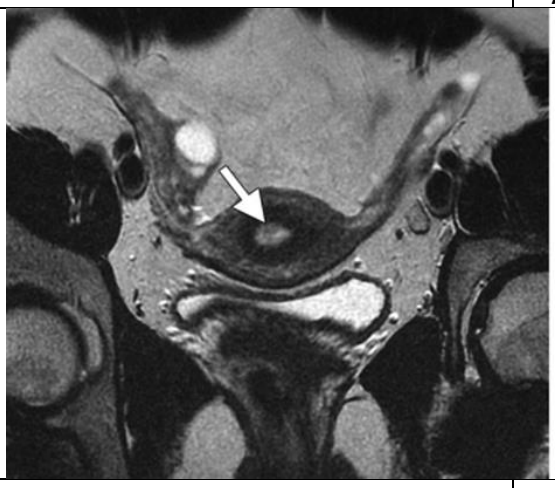
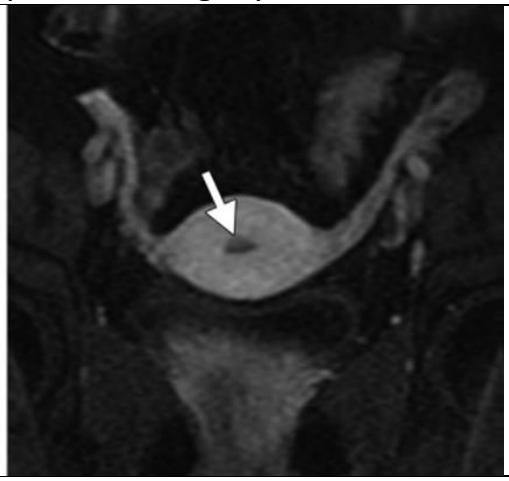
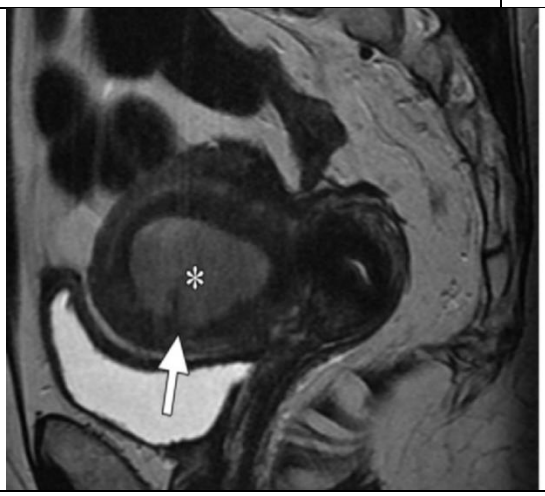
Relation of Tumor to Myometrium:

- Normal myometrium enhances intensely compared with hypointense endometrial tumor.
- Maximum contrast between hyperintense myometrium and hypointense endometrial tumor occurs 50–120 seconds after contrast medium administration

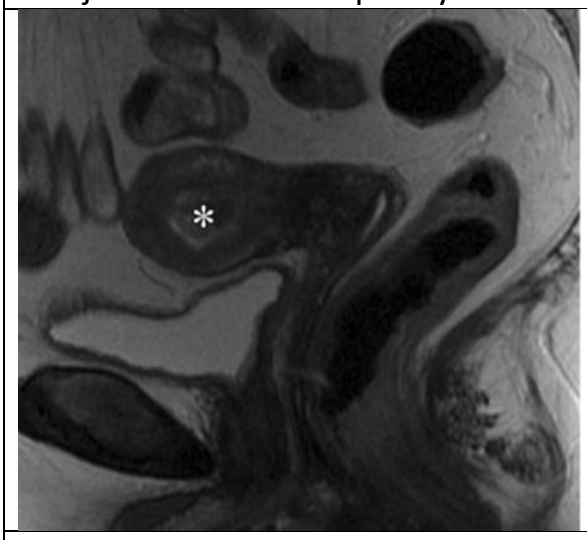
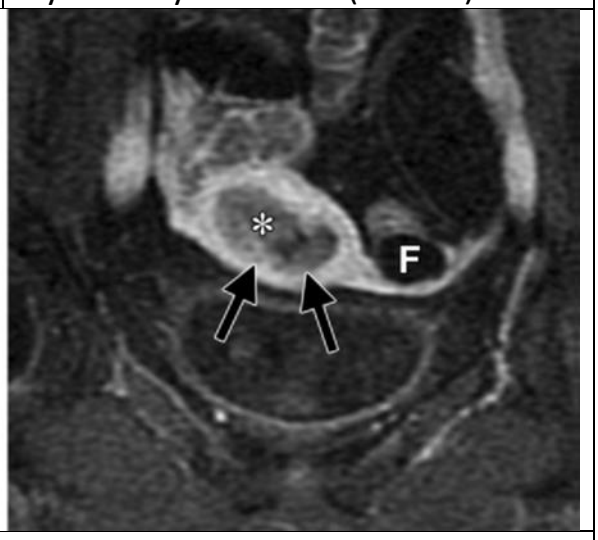
❖Diffusion- Weighted Imaging:

- **DWI:** Endometrial cancer exhibits impeded diffusion compared with surrounding tissue, manifesting with high signal intensity
- **ADC map:** low signal intensity
- ADC value of endometrial cancer = 0.8 X10-3 mm2/sec
  which is significantly lower than that of
- ADC value of normal endometrium = 1.5X10-3 mm2/sec.

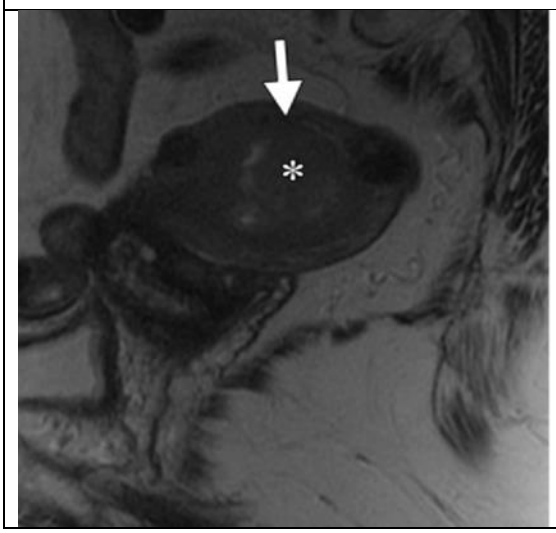
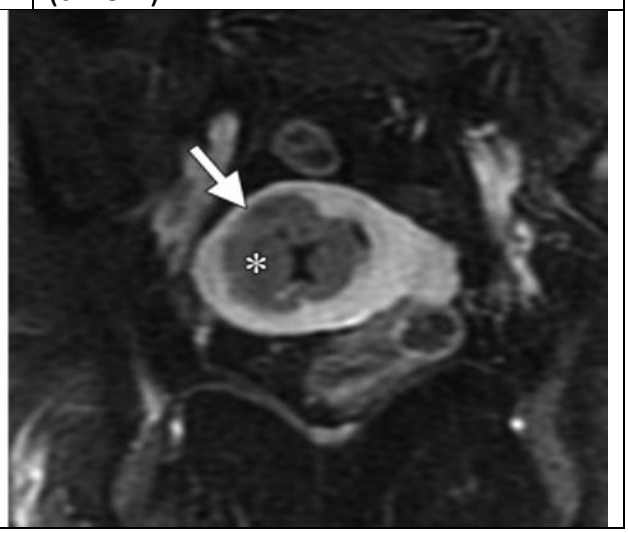
❖ Stage IA

Axial Oblique T2: intermediate-signal tumor (arrow) within the hyperintense endometrial cavity	Axial oblique dynamic contrast enhanced MRI: tumor (arrow) is hypoenhancing relative to hyperenhancing myometrium
	
Sagittal T2: shows distention of the endometrial cavity by an intermediate-signal tumor	Sagittal dynamic contrast enhanced MRI demonstrates excellent contrast between the hyperenhancing myometrium and the endometrial tumor (*)
	

❖ Stage IA

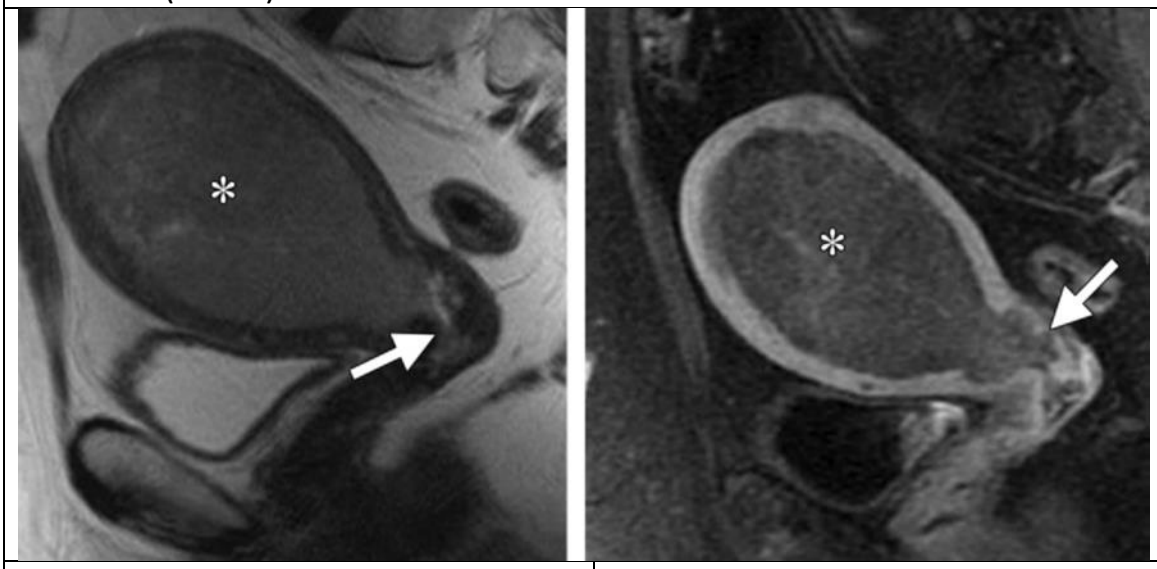
Sagittal T2: shows hypointense tumor (*) in the endometrial cavity. The junctional zone is poorly defined	Axial oblique dynamic contrast enhanced MRI: Invasion of the inner layer of myometrium (arrows).
	

❖ Stage IB

Sagittal T2: shows a large iso- to hypointense endometrial tumor (*) with poor tumor-to-myometrium contrast (arrow).	Axial oblique dynamic contrast-enhanced MRI: shows tumor enhancement (*) with invasion of the outer half of the myometrium (arrow).
	

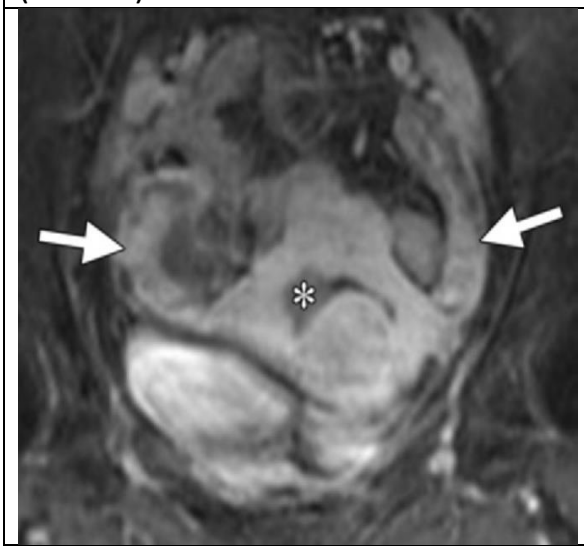
❖ Stage II

- Distention of the endometrial cavity by a tumor (*) that extends into the cervix (arrow).



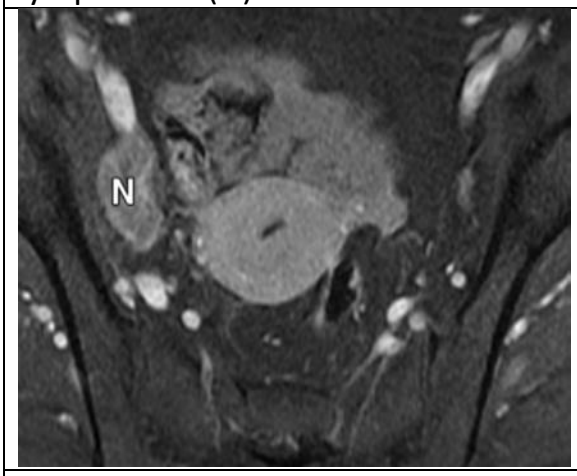
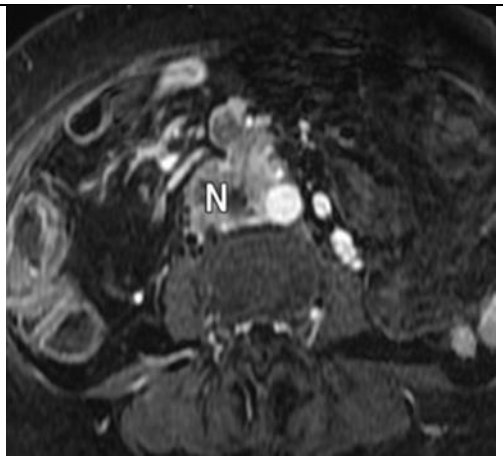
❖ Stage IIIA

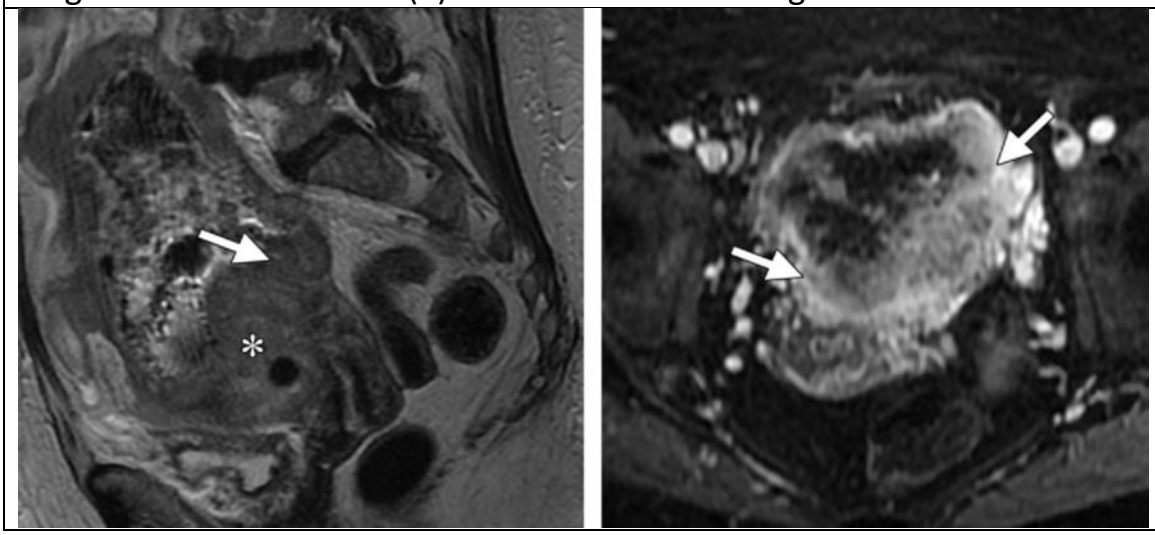
Extension of the endometrial tumor (*) into both fallopian tubes (arrows).



❖ Stage III B

Large, isointense endometrial tumor (*) with extension into the upper aspect of the vagina (arrow)

❖ Stage III C1	❖ Stage III C2
An enlarged right external iliac lymph node (N)	Large Para-aortic LN
	

❖ Stage IV A
Large endometrial tumor (*) with invasion of the sigmoid colon


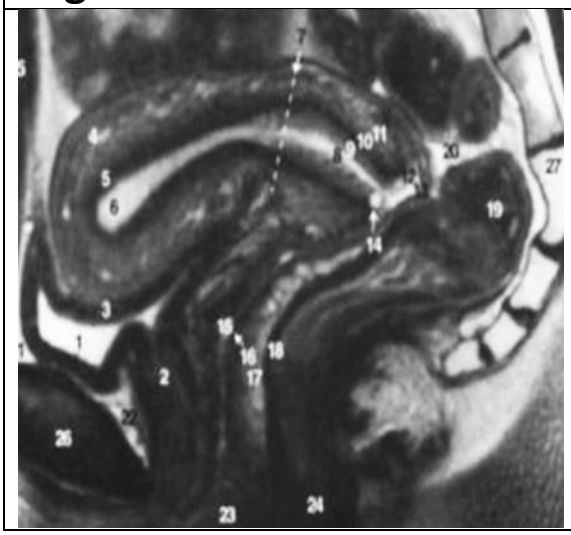
Female Genital System

Cervix

MRI Zonal Anatomy

<u>T2 => Cervix => 3 Layers</u>

1) Central area of epithelium and mucus in the cervical canal => high signal
2) Inner zone of fibrous stroma => low signal.
3) Outer zone of smooth muscle => intermediate signal.

Sagittal T2	Axial T2
	

Cervicitis

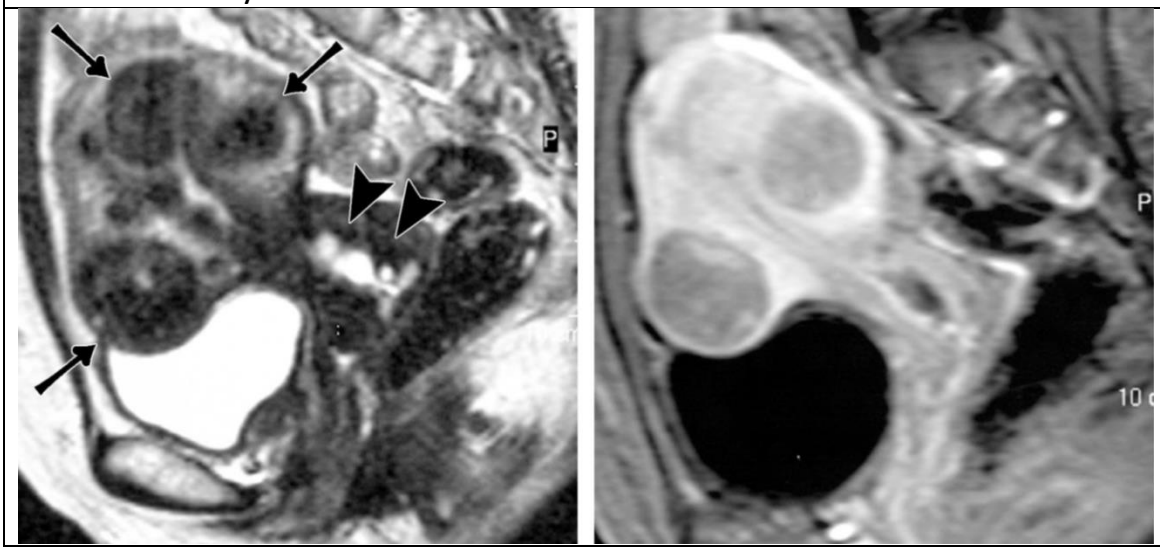
- Symptoms of acute cervicitis are a tenacious, jelly-like, yellow, or turbid discharge and a sensation of pelvic pressure or discomfort.

Causative Organism:

- Trichomonas vaginalis, Candida albicans, and herpes simplex virus can cause inflammation of the ectocervix.
- Neisseria gonorrhoeae and Chlamydia trachomatis infect only the glandular epithelium

MRI:

- Retention cysts in the cervix

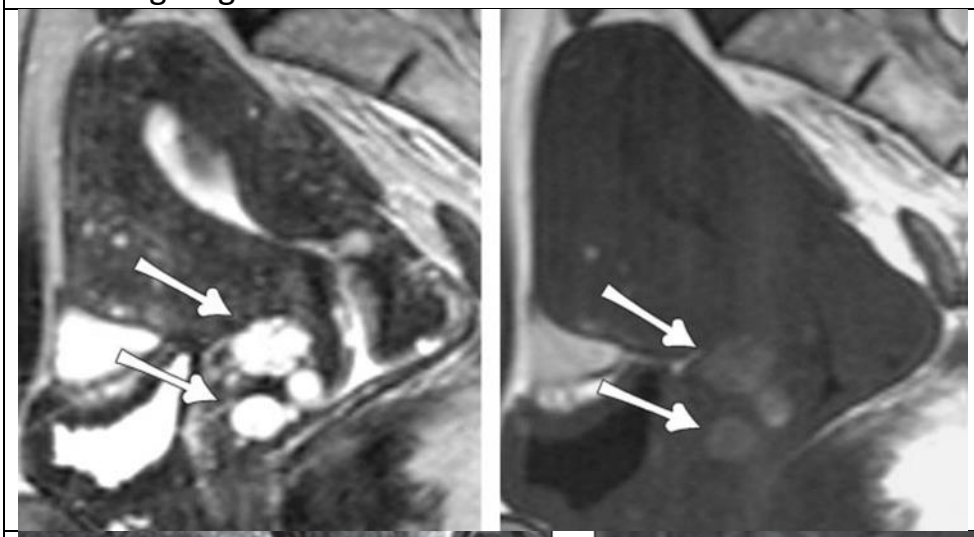


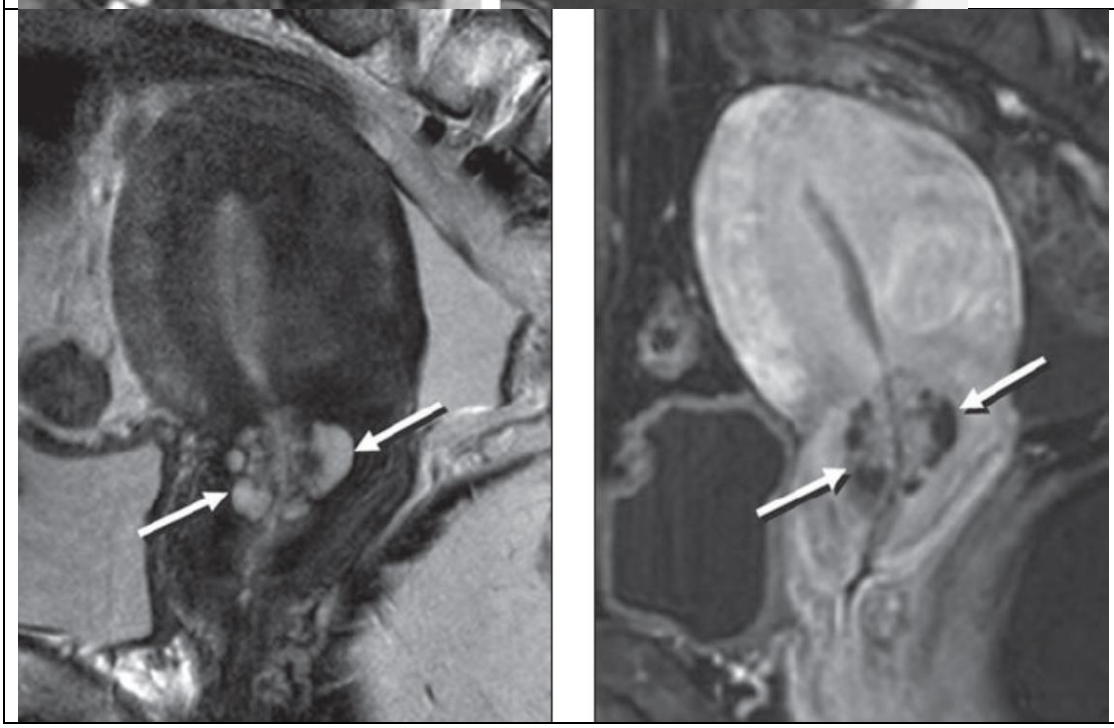
Nabothian Cyst

- Nabothian cysts are common retention cysts of the uterine cervix.
- They are formed as a result of the healing process of chronic cervicitis.

MRI:

- T1: intermediate or slightly high signal
- T2: high signal

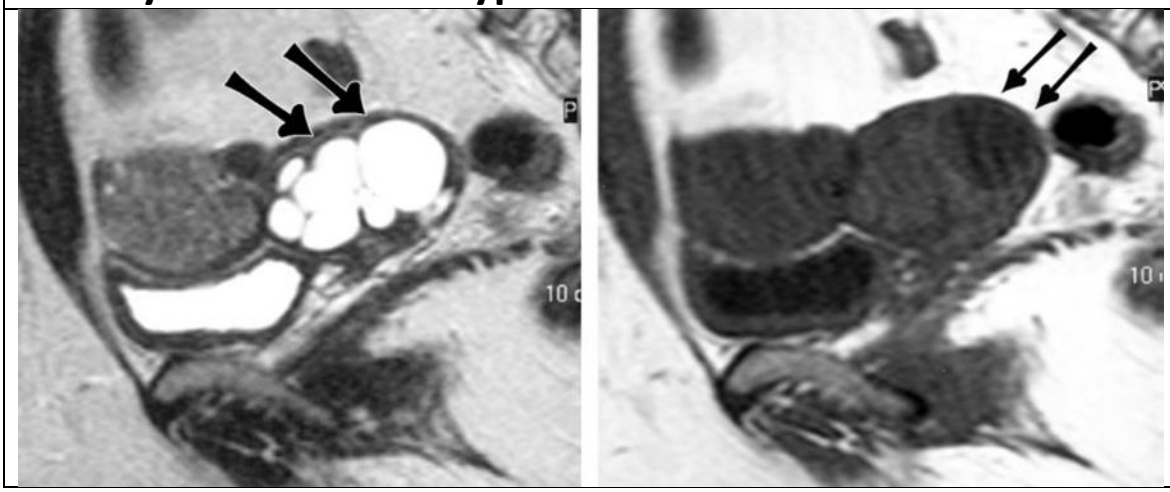




Cervical Polyp

- Cervical polyps are one of the most common causes of intermenstrual vaginal bleeding.
- Most patients are perimenopausal, especially in the 5th decade of life.
- The polyps are usually pedunculated, with a slender pedicle of varying length, but some are sessile

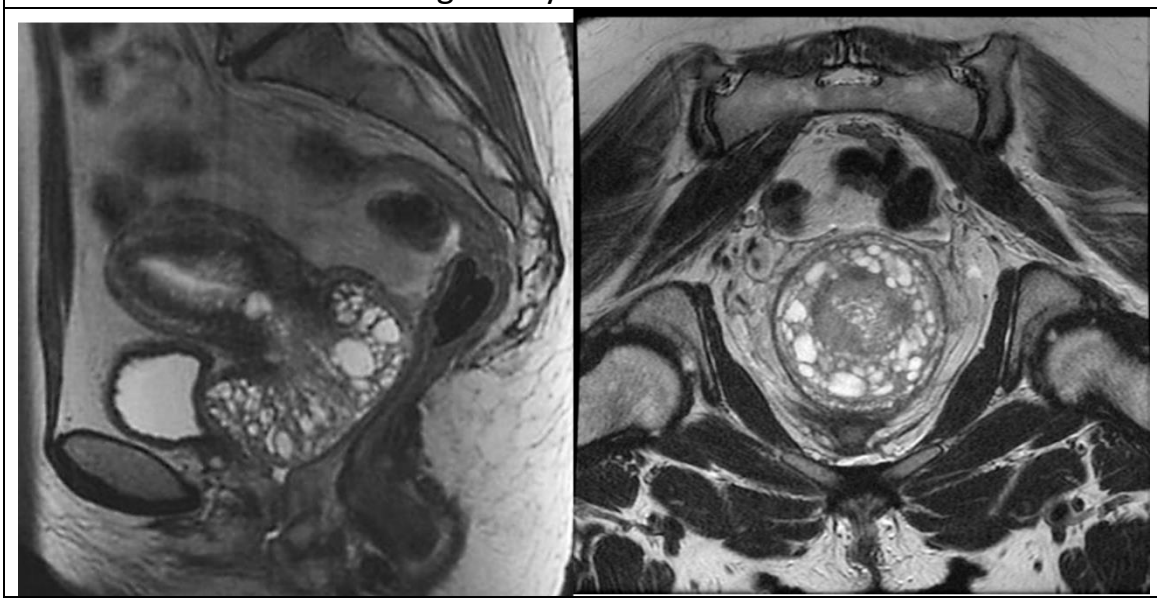
❖ Cystic Cervical Polyp



Adenoma Malignum

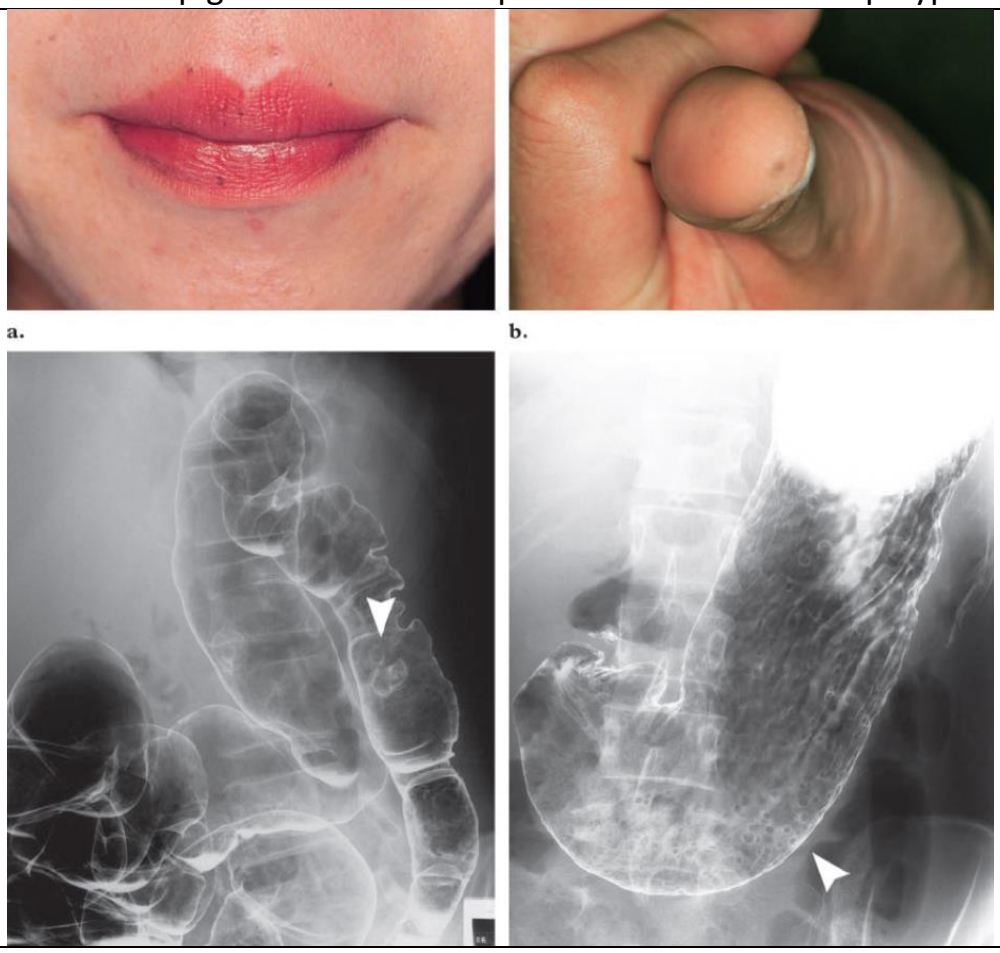
- Adenoma malignum (also known as minimal deviation adenocarcinoma) is a special subtype of mucinous adenocarcinoma of the cervix.
- 3% of all cervical adenocarcinomas
- The most common initial symptom is a watery discharge.
- Prognosis is unfavorable

- Multicystic lesions that extend from the endocervical glands to the deep cervical stroma with solid components.
- associated with Peutz-Jeghers syndrome



❖ Peutz-Jeghers Syndrome =

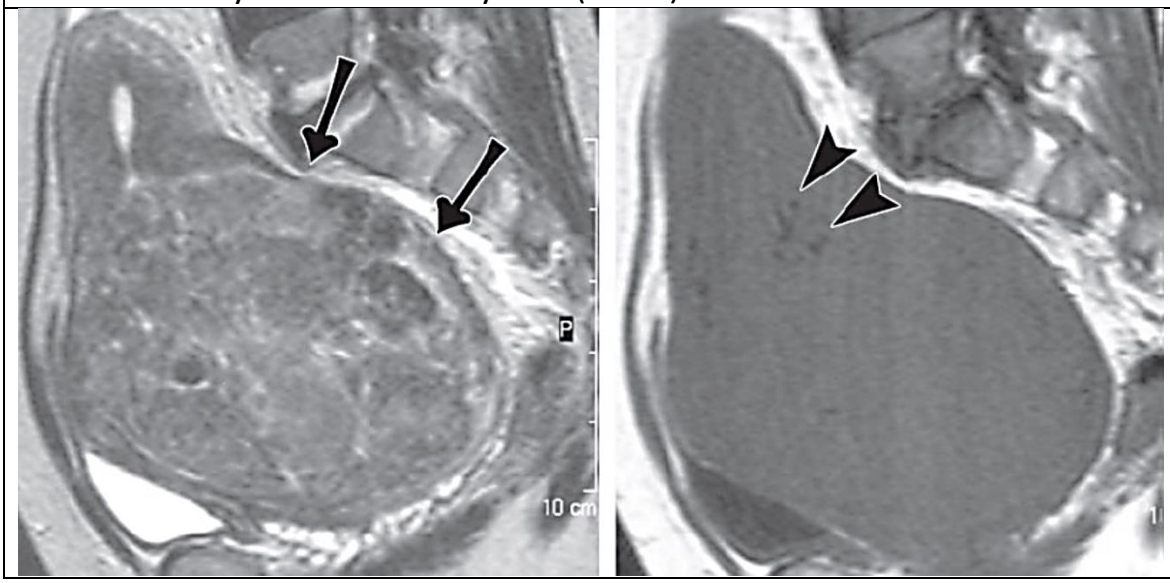
Mucocutaneous pigmentation + multiple GIT hamartomatous polyps



a. b.

Cervical Leiomyoma

As about 90% of uterine leiomyomas occur in the uterine body.
Cervical leiomyoma is relatively rare (<10%).



Cancer Cervix

- 3rd most common cancer among women after breast and colorectal cancer.
- 1st Most common malignancy affecting the female genital tract.

Age:

- 35 and 50 years.

Screening Program:

- Cytologic screening program has been widely applied in Japan in the past 20 years.
- using a Papanicolaou smear.
- The prevalence of invasive squamous cell carcinoma has decreased

Risk Factors:

- Smoking
- Immunosuppression
- Sexual activity
- Human papilloma virus.

Histopathology:

90% of cervical carcinomas

- **Squamous cell origin.**

The remainder being:

- Aenocarcinomas
- Adenosquamous carcinomas.
- Malignant melanoma
- Sarcoma
- Lymphoma
- Small cell carcinoma.

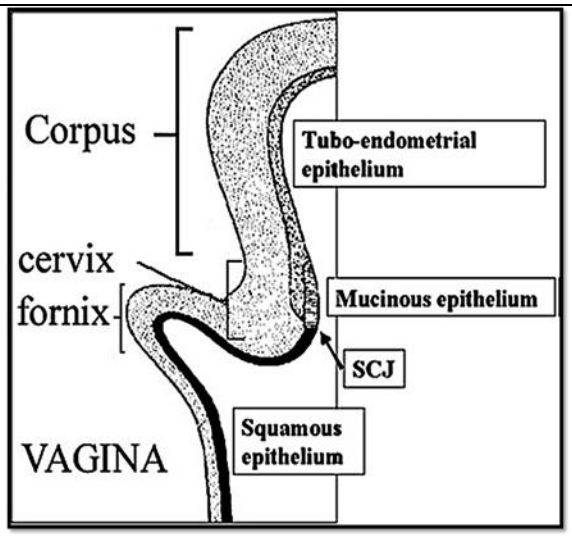
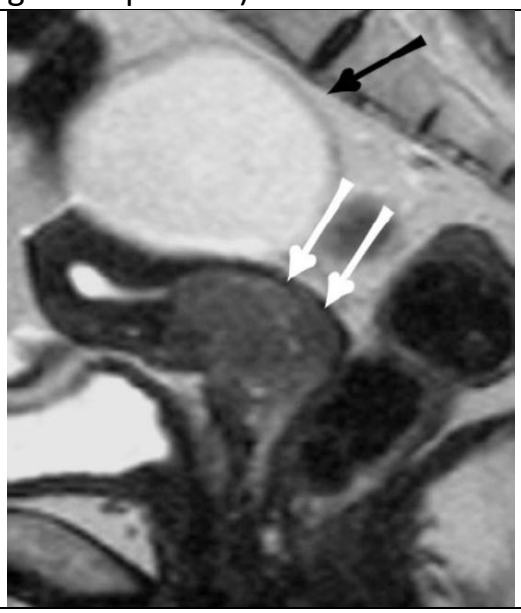
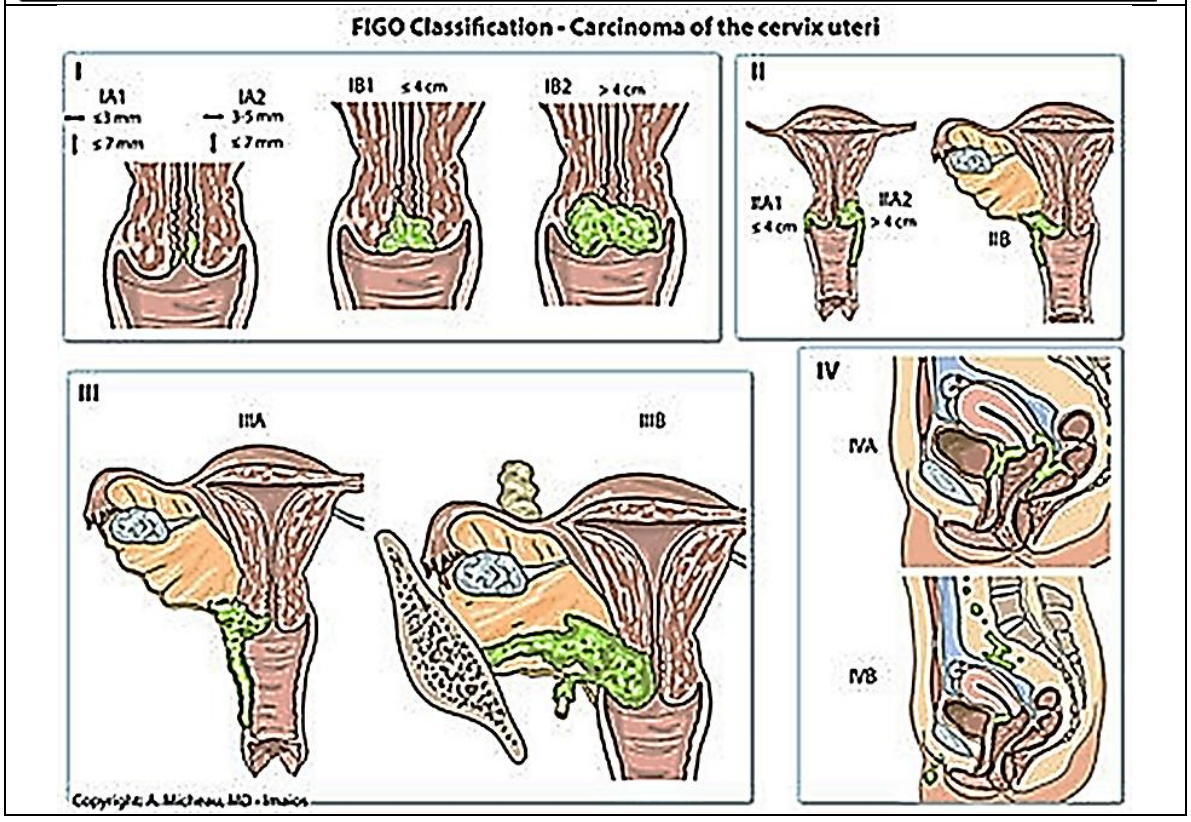
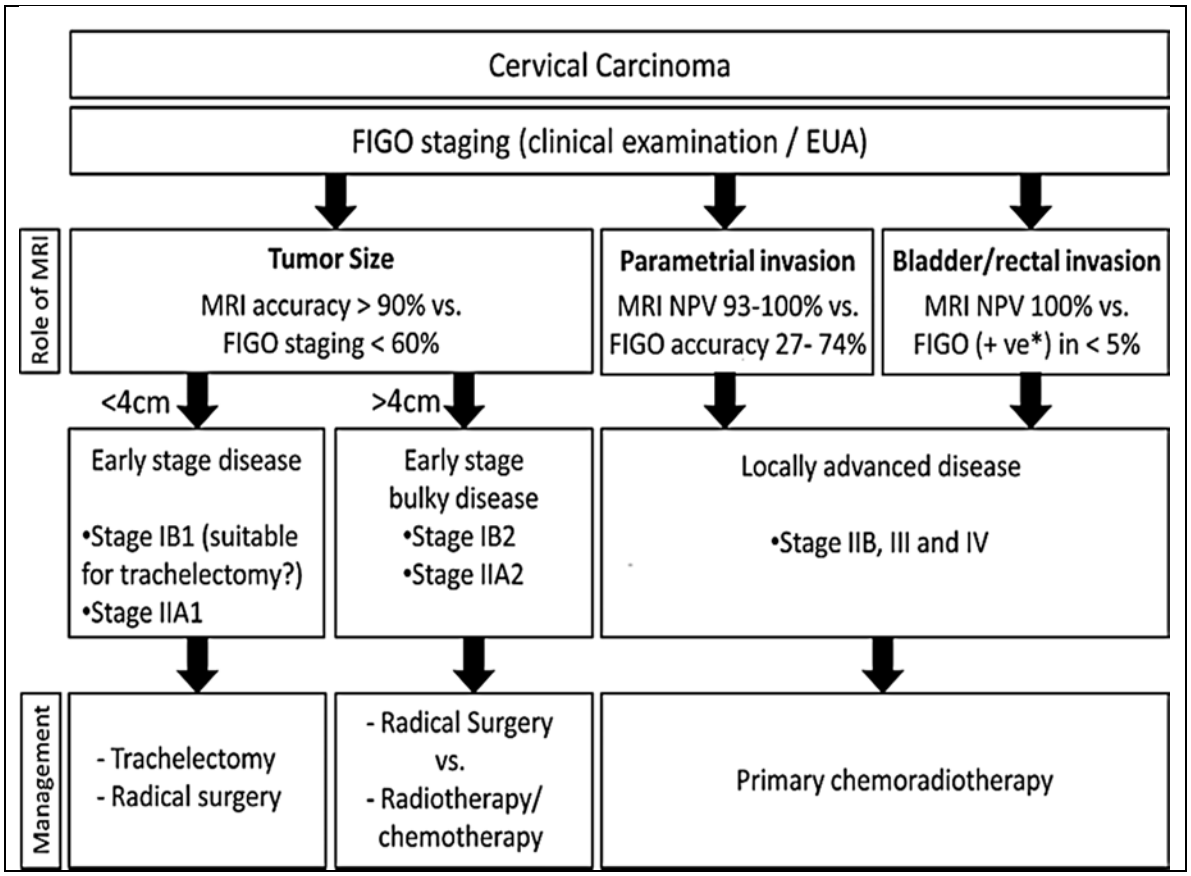
Most cervical squamous cell carcinomas grow at the SCJ = Squamocolumnar junction.	
❖ In younger women:	**❖ In elderly patients:**
SCJ is located outside the external uterine os.	SCJ is located within the cervical canal.
The tumor tends to grow outward (exophytic growth pattern).	Cervical cancer tends to grow inward along the cervical canal (endophytic growth pattern)
	

Table 1 Correlation between FIGO staging of uterine cervix cancer and MRI findings[17].

Stage		MRI T2-weighted sequence
Ia	Microinvasor	No tumor evidence
Ib	Invasive, confined to the cervix	Hyperintense tumor on T2-weighted sequence in contrast with hypointense signal from cervical stroma
Ib1	Clinically visible lesion ≤ 4 cm	Tumor partially or completely replacing the hypointense cervical stroma, not surpassing the parametrial interface represented by a hypointense halo
Ib2	Clinically visible lesion > 4 cm	
IIa	Tumor invades the upper vaginal third, but does not affect the lower vaginal third	Segmental interruption of hypointense signal on the upper third of the vaginal wall
IIb	Tumor invades the parametrium, but not the pelvic wall neither the lower vaginal third	Hyperintense tumor interrupting hypointense halo of the interface between cervical stroma and parametrium
IIIa	Involvement of the lower vaginal third, without affecting the pelvic wall	Segmental interruption of the hypointense signal of the lower vaginal third
IIIb	Pelvic wall involvement or hydronefrosis	Tumor extending to the musculature (internal obturator muscle, piriform muscle or levator ani muscle) or causing hydroureter
IVa	Tumor invades the bladder or rectum mucosa	Loss of hypointense signal of the internal wall (mucosa) of the bladder or rectum
IVb	Distant metastasis	Distant metastasis



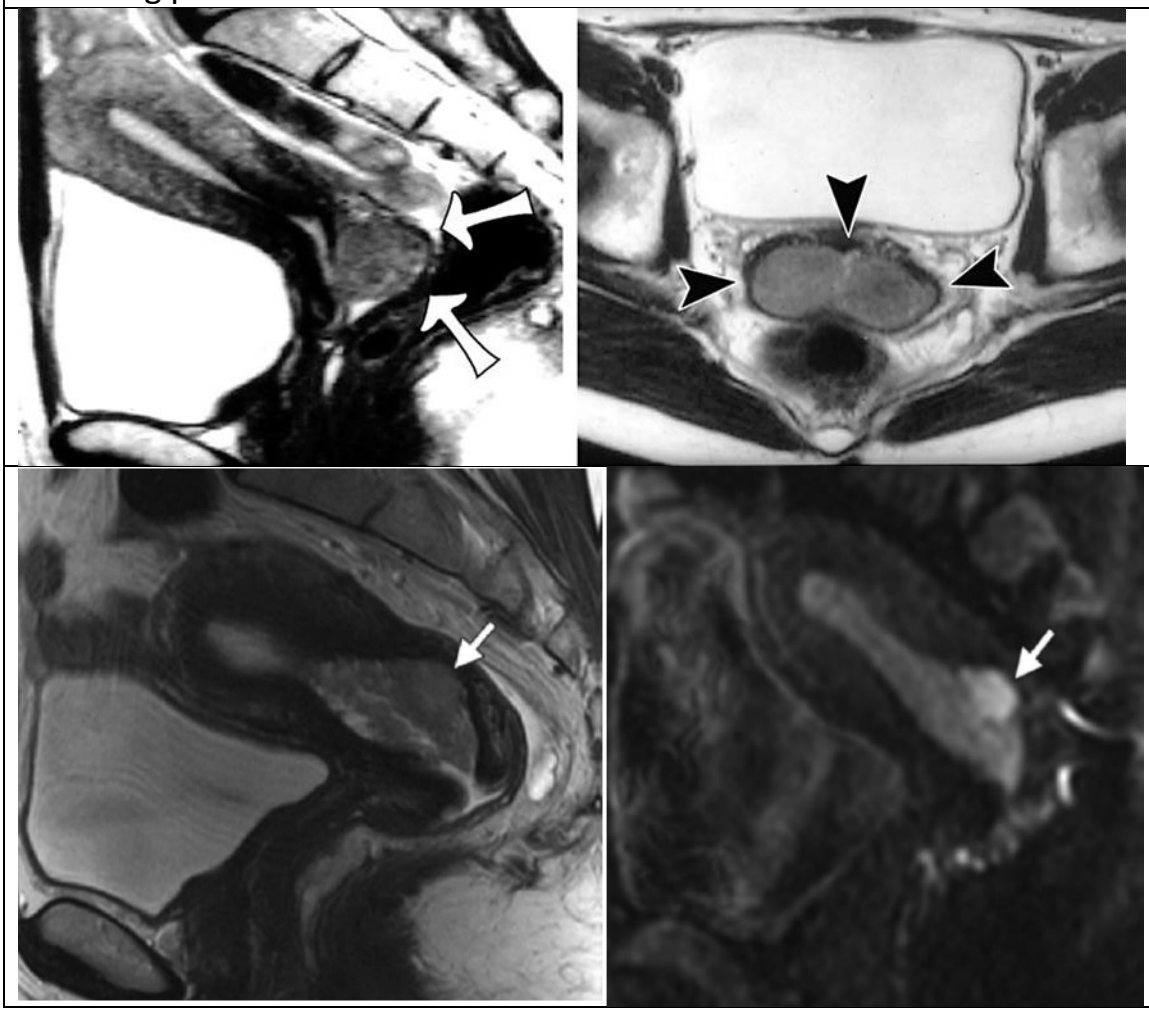


Tumor MRI signal

- T1 WI: Intermediate signal.
- T2 WI: High signal, compared to normal low signal cervical stroma.

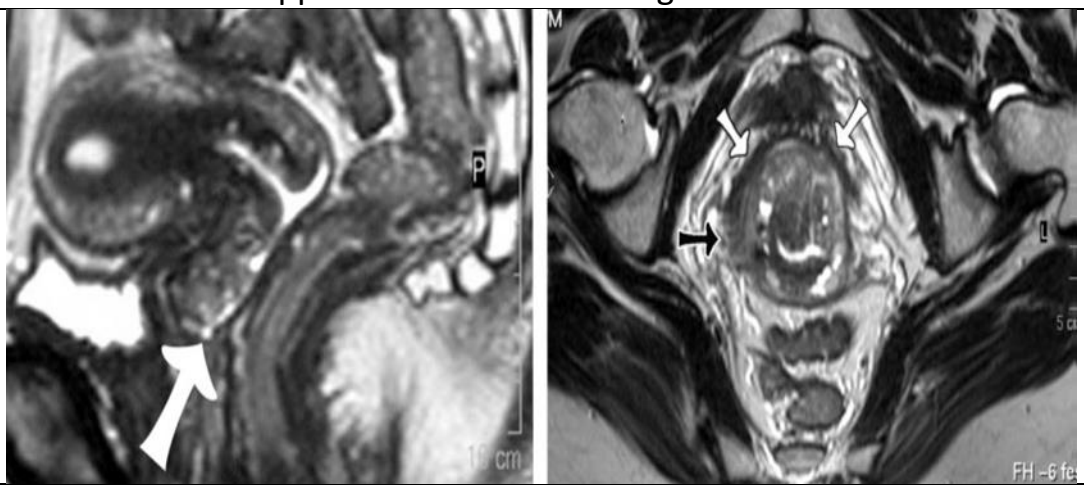
Stage Ib

The tumor is completely surrounded by hypointense cervical stroma. excluding parametrial invasion



Stage IIa

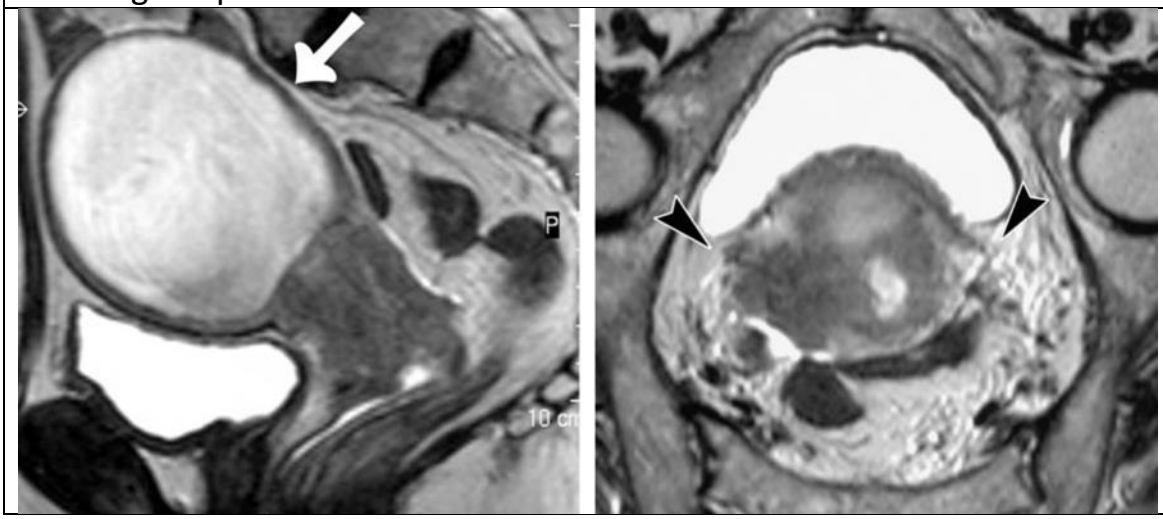
Tumor invades the upper two-thirds of the vagina.



Stage IIb

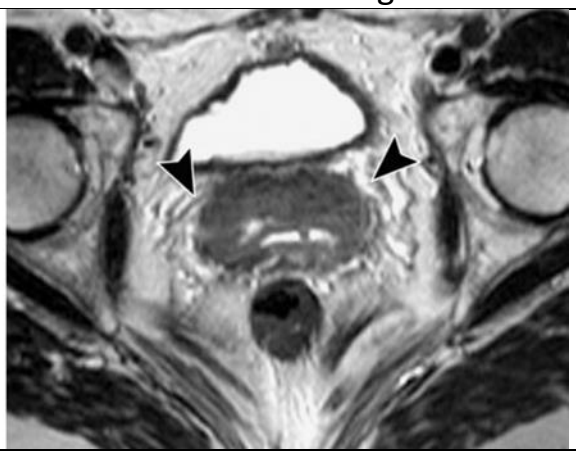
Tumor with intermediate SI replacing the normal low-signal-intensity cervical stroma.

Tumor invades beyond the uterus with parametrial invasion without reaching the pelvic wall



Stage IIIa

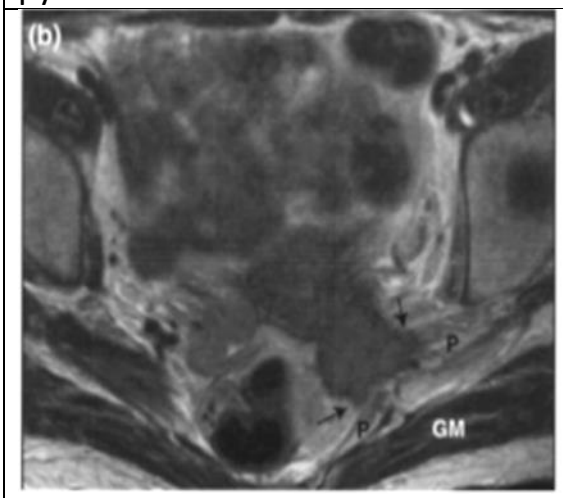
Tumor intermediate signal extends to the lower third of the vagina



Stage IIIb

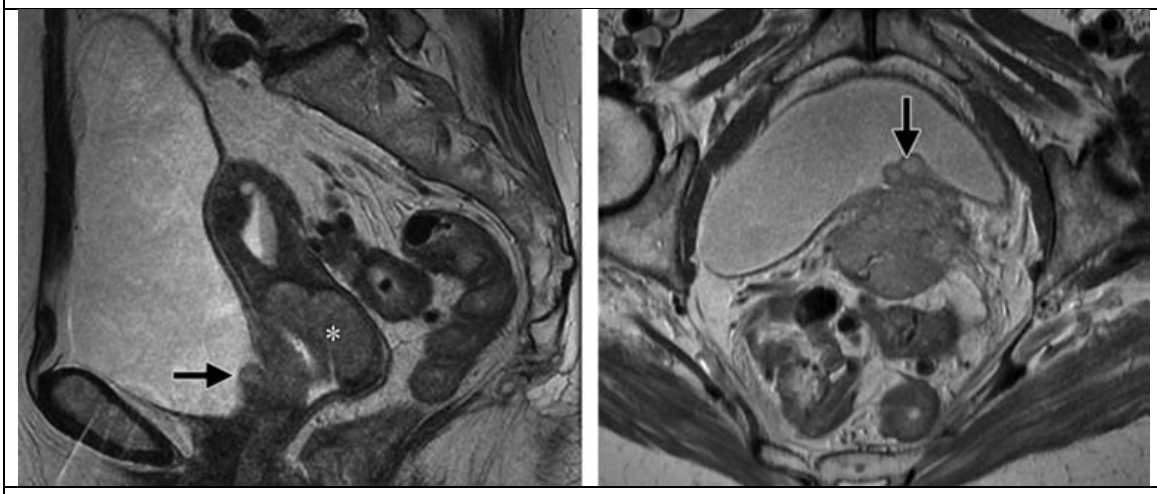
Cervical cancer with uterosacral extension.
Lateral pelvic wall muscles:
Obturator internus, levator ani, and pyriform muscles and the iliac vessel

Tumor extends to the pelvic wall muscles or causes hydronephrosis



Stage IVa

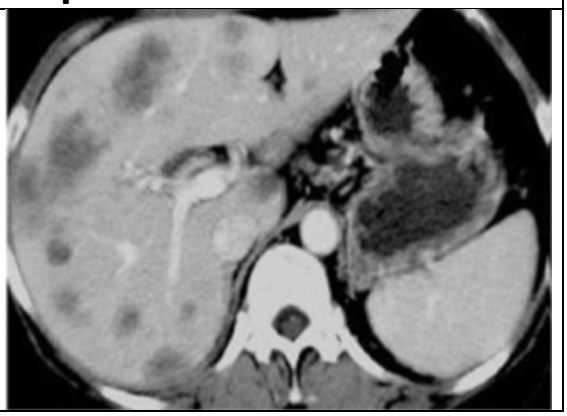
Cervical cancer invades UB



Stage IVb

Para-aortic LNs

Hepatic Metastasis

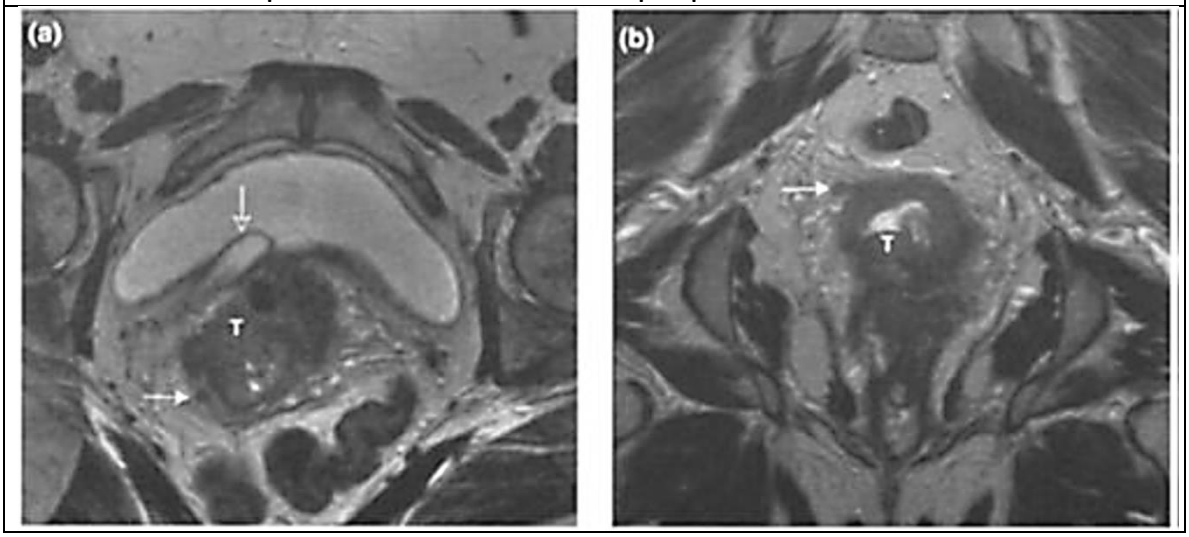


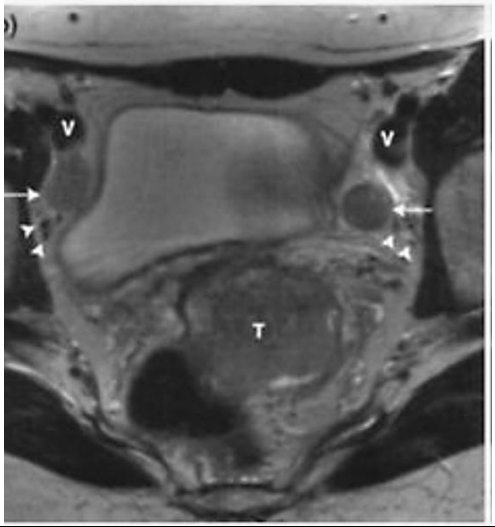
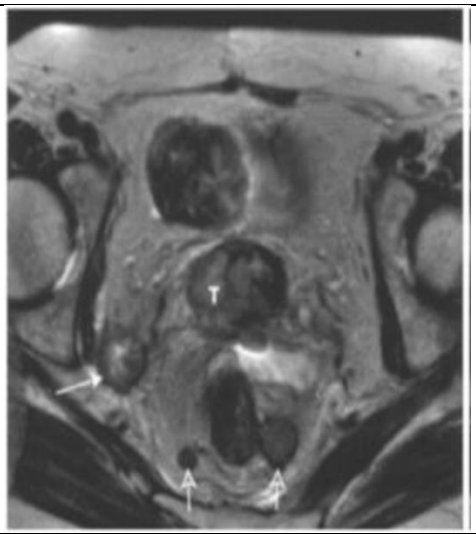
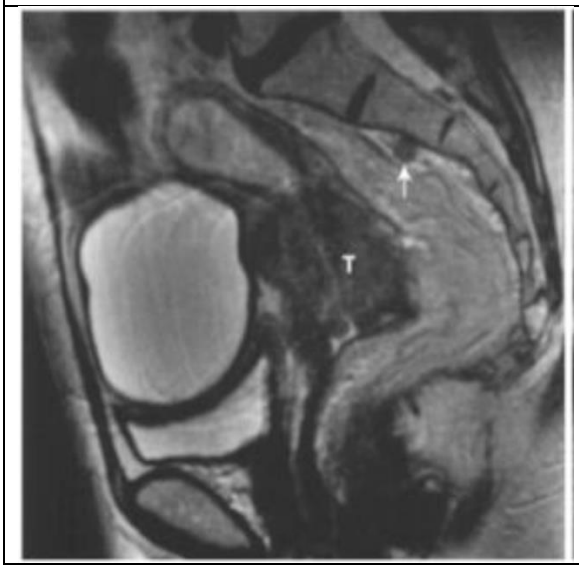
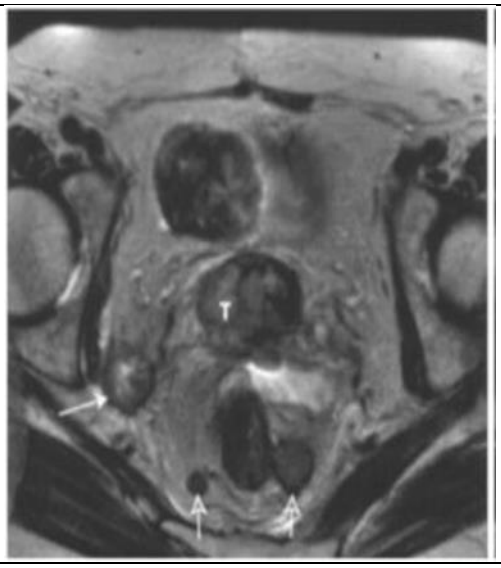
Nodal Spread

- Short axis diameter > 1 cm.
- Round shape
- Asymmetrical cluster of nodes on the pelvic sidewall
- Nodal T2-weighted signal intensity similar to the primary tumour.
- Central nodal necrosis is an accurate positive predictor of metastasis even in normal sized lymph nodes.

Paracervical/Parametrial LN

Local lymphatic spread to the paracervical and parametrial nodes is often not identified separate from the tumour proper.

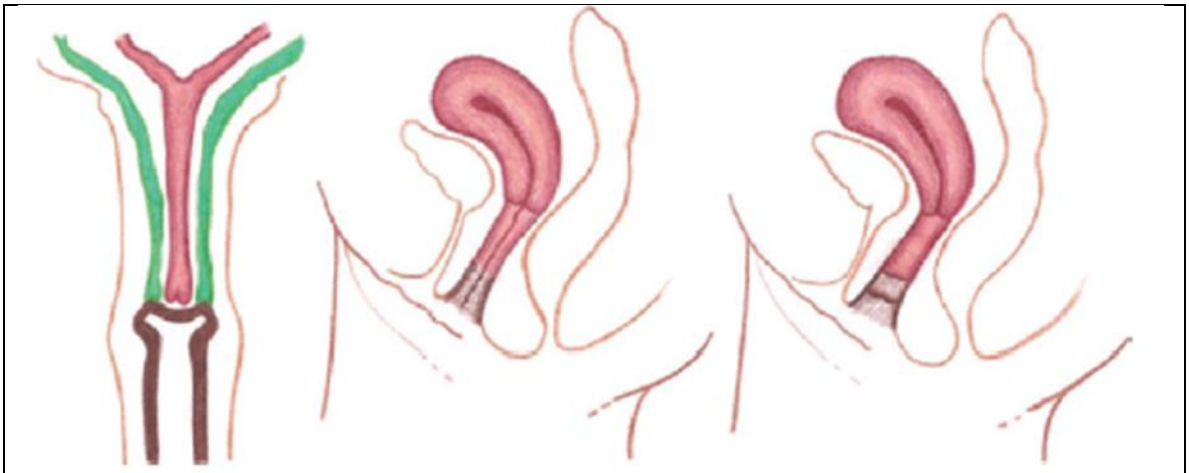


Bilateral obturator LNs	Internal iliac LN
	
Pre-sacral LN	**Mesorectal LN**
	

Female Genital System

Vagina

Vagina Embryology



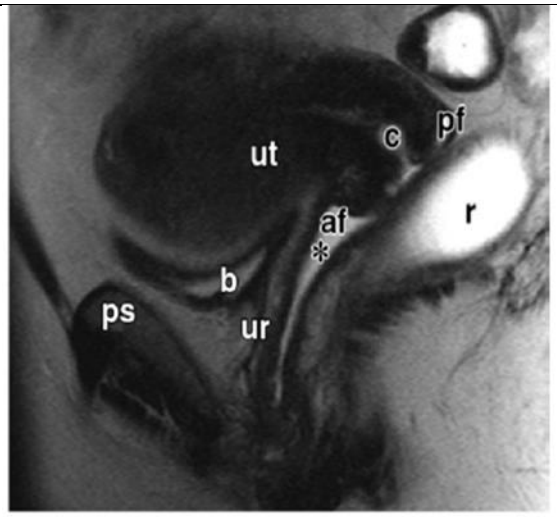
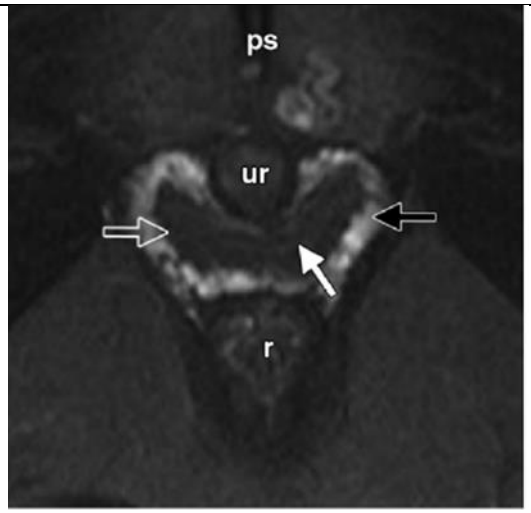
- **Müllerian ducts (red)** develop into => uterus, cervix, and upper two-thirds of the vagina,
- **Sinovaginal bulbs (brown) which arise from the urogenital sinus** develop into => lower third of the vagina.
- **Wolffian ducts (green),** the precursors of the male internal genitalia, usually regress in the female; however, remnants may lead to cystic structures in the upper vagina (Gartner duct cysts)

Vagina MRI T2 Zonal Anatomy

- Fibromuscular sheath or tube extending from the vulvar vestibule to the uterus.

3 Layers:

- Central mucus is thickest and has the highest T2 signal during the midsecretory phase of the menstrual cycle.
- Intermediate signal intensity of the loosely arranged circular and longitudinal muscle layers
- the outer venous plexus

Sagittal T2	Axial T2: H-shaped Vagina
	

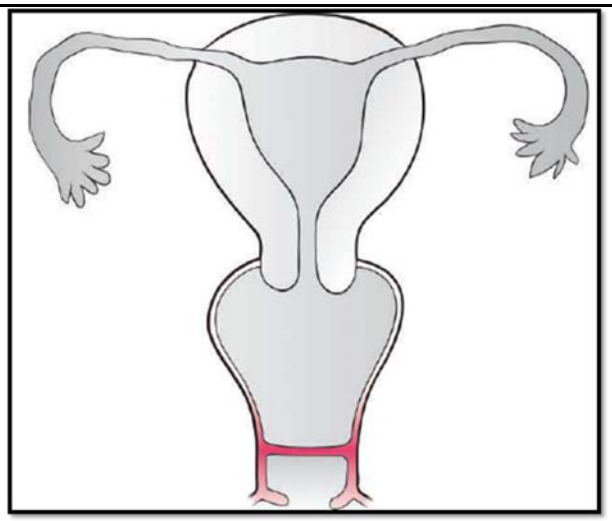
Vaginal Septum Anomalies

Classification of Vaginal Anomalies

Class	Description
I	Transverse vaginal septum (obstructing or nonobstructing)
II	Longitudinal vaginal septum (obstructing or nonobstructing)
III	Stenosis or iatrogenic cause

Class I:Transverse Vaginal Septum

- Transverse vaginal septum is a vertical fusion defect that develops when the tissue between the vaginal plate, originating from the urogenital sinus and the caudal aspect of the fused müllerian ducts, fails to resorb.
- The septum is a membrane of fibrous connective tissue with vascular and muscular components.

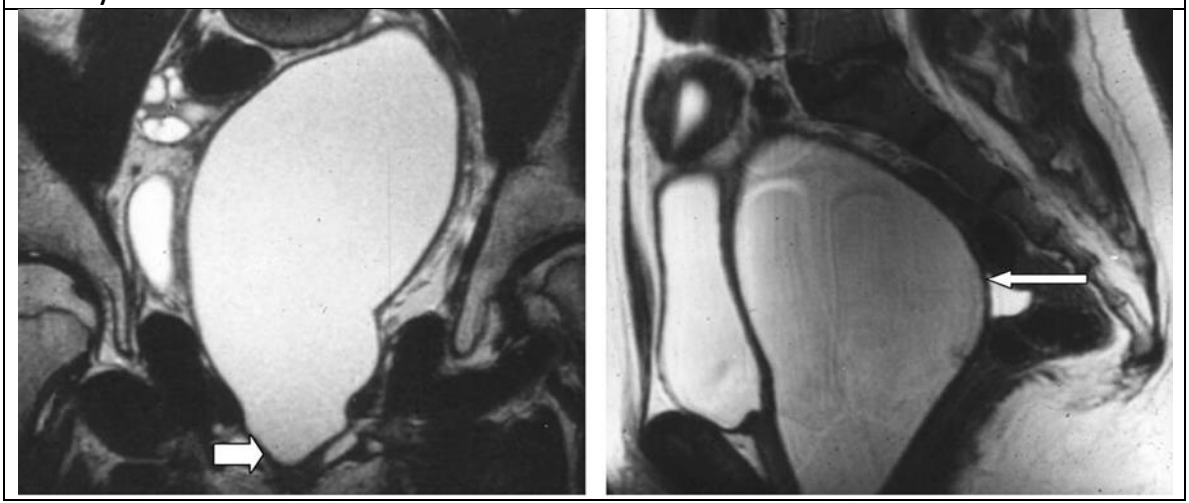


Location:

- Upper vagina (46%)
- Mid-vagina (40%)
- Lower vagina (14%)

Imaging findings:

- ***Hematocolpos*** = marked distention of the vagina.
- ***Hematometrocolpos*** = Dilatation of the endometrium in is usually less striking, secondary to decreased distensibility of the more muscular myometrium.



Class II: Longitudinal Vaginal Septum

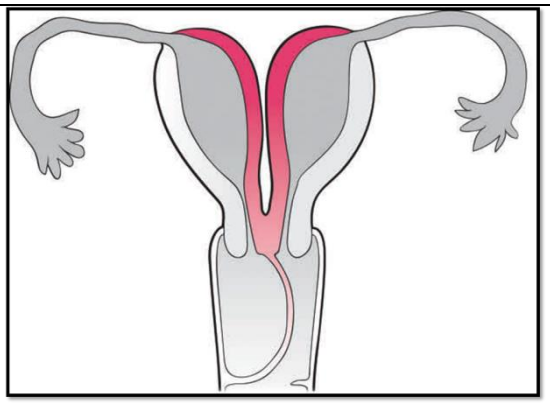
- Longitudinal vaginal septum is thought to develop as a consequence of either:

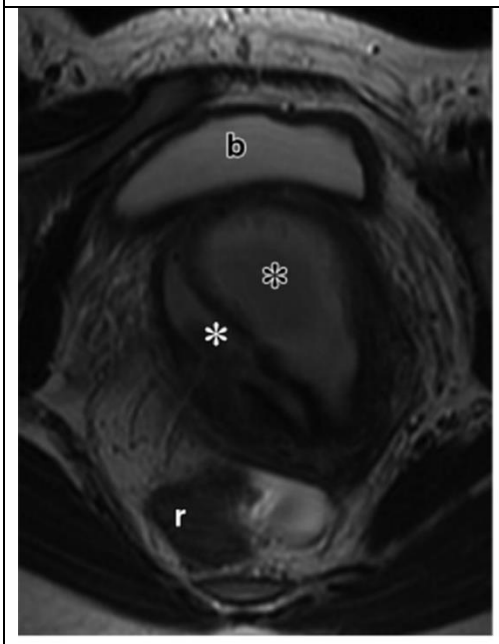
a) failure of fusion of the lateral müllerian ducts, resulting in duplication of the uterus, cervix (uterus didelphys), and vagina;

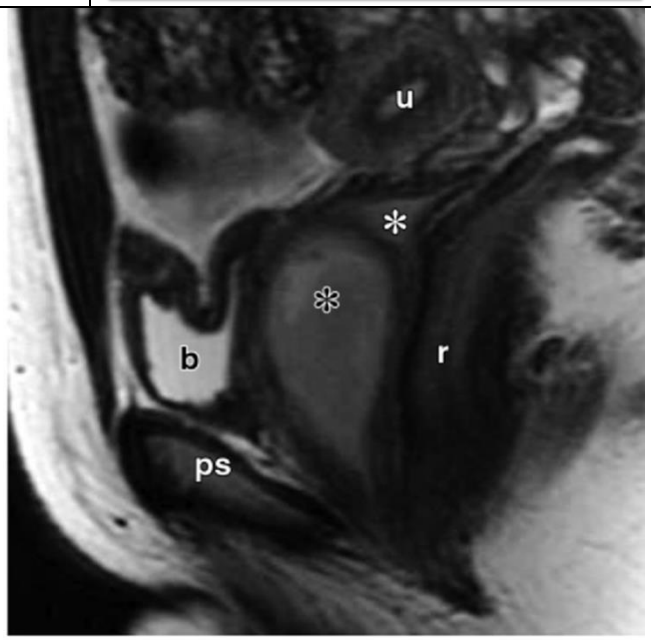
or

b) incomplete resorption of the vaginal septum, which may or may not be obstructive

Longitudinal vaginal septa may occur in association with uterine anomalies, most commonly in cases of ***uterus didelphys.***

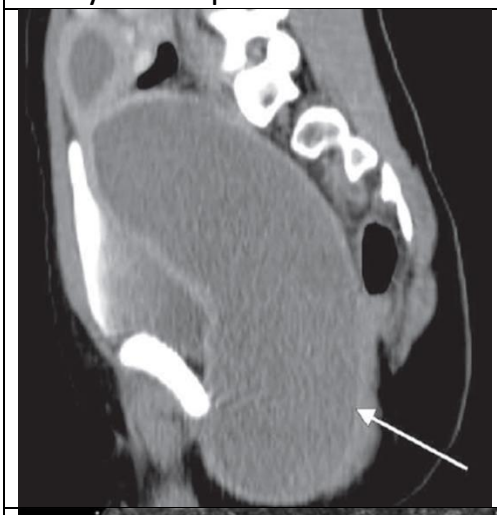


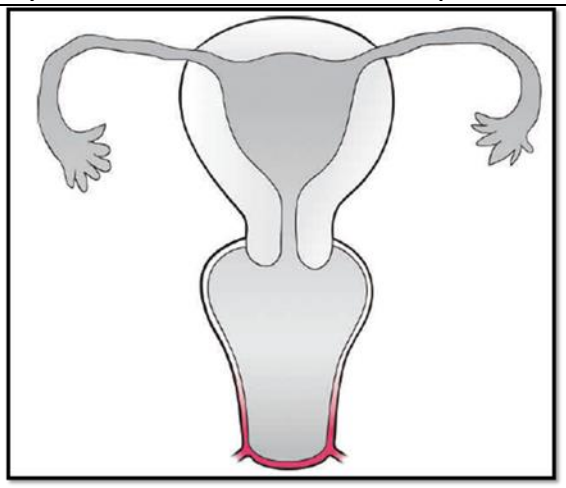


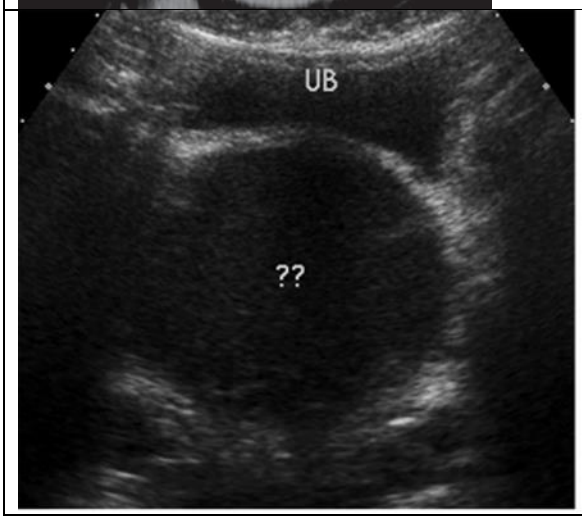


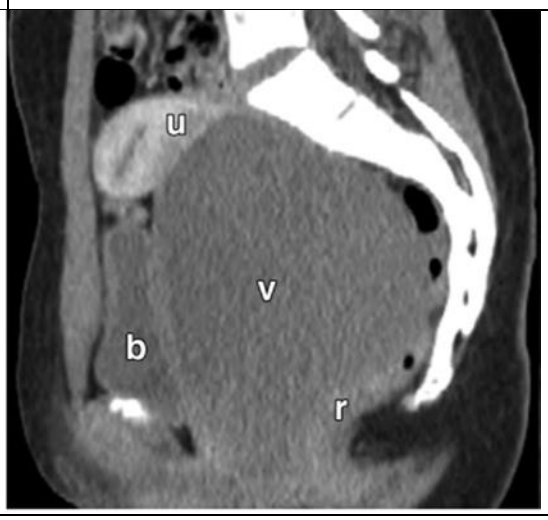
❖ Imperforate Hymen

- The hymen is a normally occurring membranous fold that wholly or partially occludes the external orifice of the vagina and is usually perforated.
- Complete closure is the most commonly identified type of hymenal abnormality
- Although not an Mullerian Duct Anomaly, an imperforate hymen can have clinical and imaging characteristics similar to those of a low transverse vaginal septum.
- At the 5th month, the solid vagina begins to recanalize. Imperforate hymen represents a failure of the very end of the recanalization process.





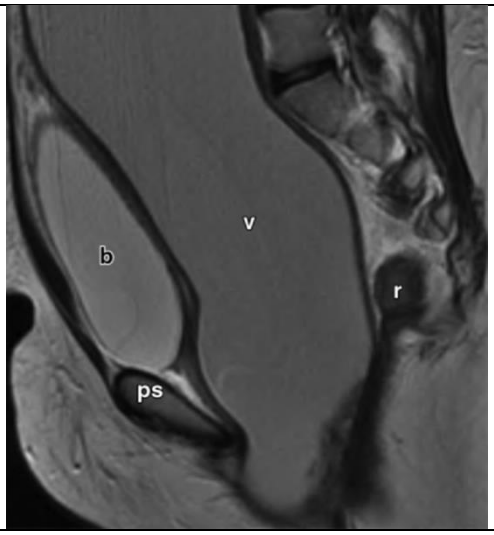




❖ Vaginal Agenesis

- occurs when the sinovaginal bulb does not form
- In the isolated form of vaginal agenesis with a normally functioning uterus, patients develop hematometra and present with primary amenorrhea and severe cyclic pelvic pain.
- Although vaginal agenesis can be diagnosed at physical examination, adjunct cross-sectional imaging is often performed, especially in patients who present with a palpable abdominal mass.

- Sagittal MR image shows a massively dilated vagina (v) containing blood products.



Cystic Lesions

1) Gartner Duct Cyst

- Embryologic secretory retention cysts
- Arise from the residual wolffian (mesonephric) duct remnant

Location:

- Anterolateral vagina
- Above the level of the most inferior aspect of the pubic symphysis.
- No urethral communication or displacement or deformity.

Imaging findings:

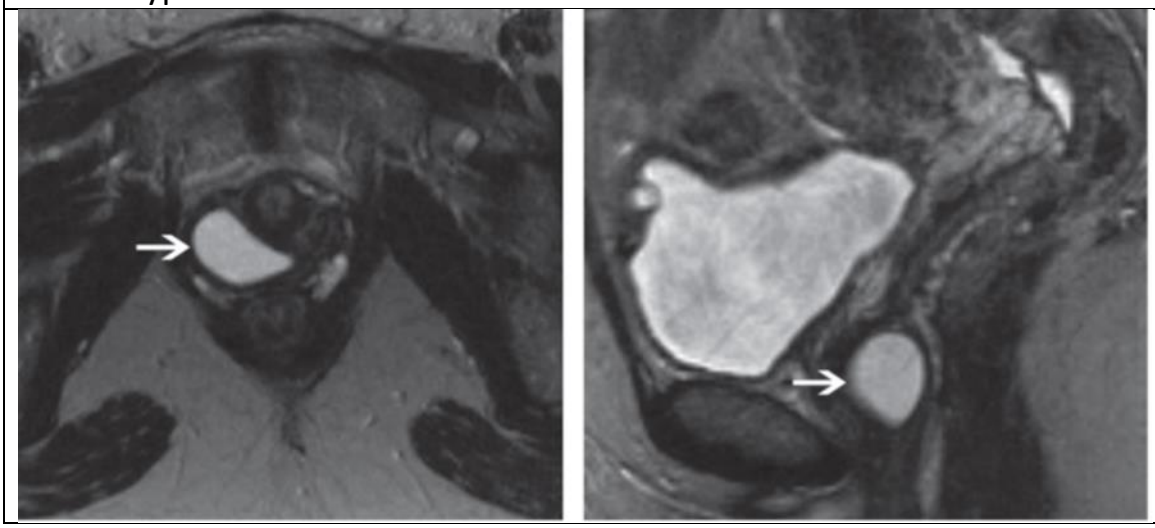
- Solitary cyst
- < 2 cm
- may contain septa

If content is simple fluid =>

- T1: Hypointense
- T2: hyperintense

If hemorrhagic or proteinaceous content =>

- T1: Hyperintense
- T2: Hypointense



2) Bartholin Gland Cyst

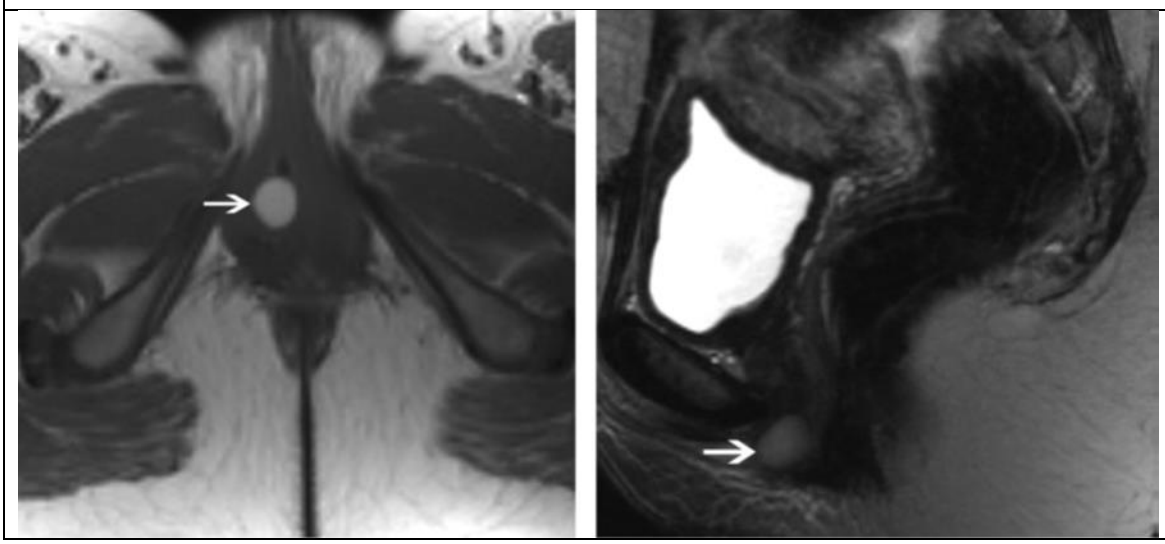
- Bartholin glands are small glands located on either side of the posterolateral vagina that are derived from the urogenital sinus and are lined with transitional or columnar epithelium
- Caused by chronic inflammation or infection of the underlying glands, resulting in ductal obstruction from purulent material or mucus.

Location:

- Posterolateral inferior third of the vagina medial to the labia minora
- At or below the level of the pubic symphysis.

Imaging findings:

- usually unilocular
- 1–4 cm in size
- T2: hyperintense
- T1: variable appearances depending on their proteinaceous or mucinous content



3) Skene Duct Cyst

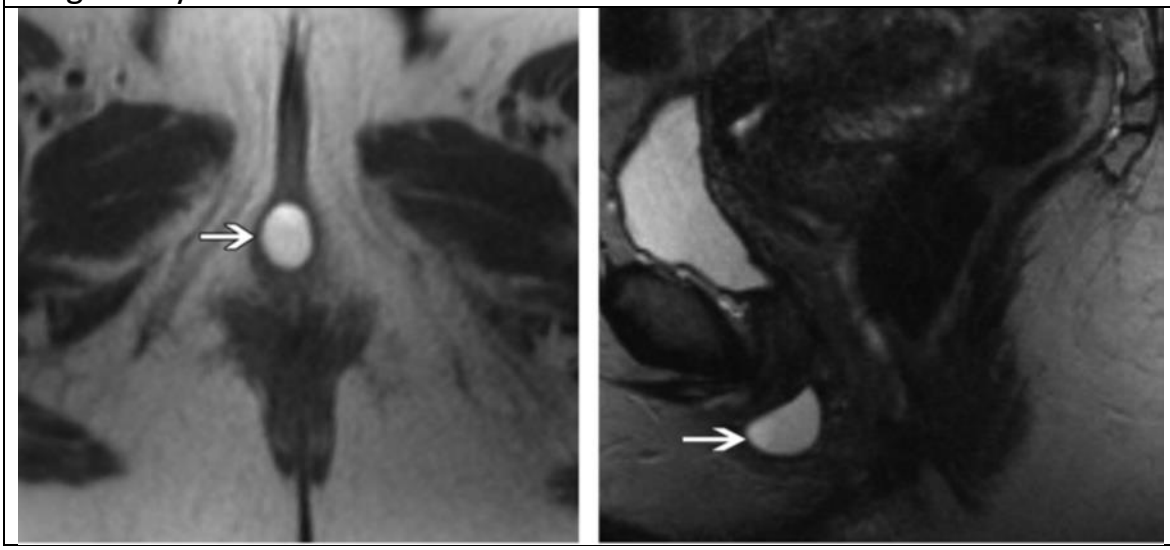
- Retention cysts lined with stratified squamous epithelium
- Caused by inflammatory obstruction of the paraurethral ducts.

Location:

- Lateral to the external urethral meatus
- Inferior to the pubic symphysis.

Imaging findings:

- Round or oval
- T2: hyperintense lesions
- It may be difficult to distinguish between Skene duct cysts and Bartholin gland cysts due to their similar location.



4) Urethral Diverticulum

- Protrusions of the urethra into the periurethral fascia.
- its epithelial lining is identical to the urethral mucosa,
- Communication with the urethral lumen is maintained .
- 0.6%–6% of women have urethral diverticula,
- Age: can occur at any age, mostly (3rd to 5th decades.)

i. Acquired Diverticulum:

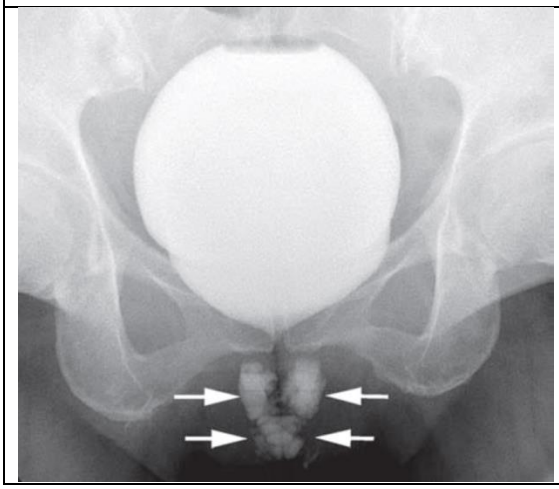
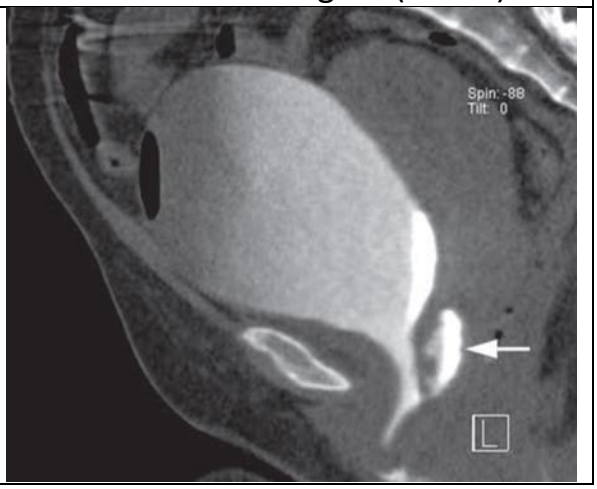
- The vast majority of urethral diverticula are from acquired causes,
- The most widely accepted theory involving rupture of a chronically obstructed and infected periurethral gland into the urethral lumen.
- The outpouching epithelializes over time and becomes a true diverticulum lined with urothelium
- Escherichia coli and, less often, gonococci and Chlamydia species are the most common infectious causes.

ii. Congenital Diverticulum:

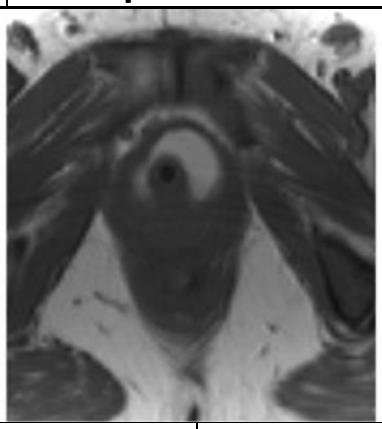
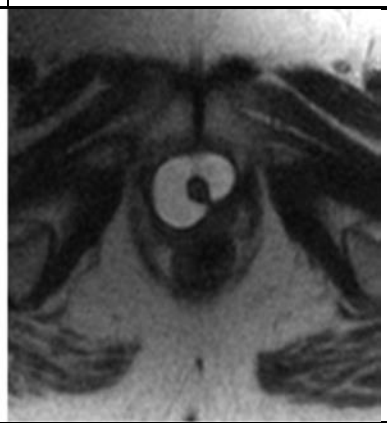
- A pediatric urethral diverticulum is rare and is likely congenital.

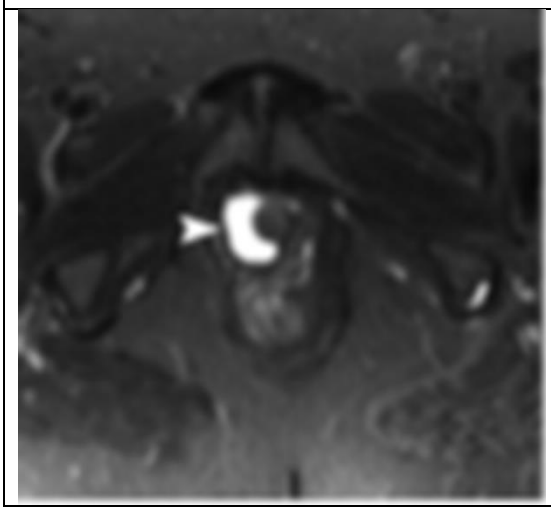
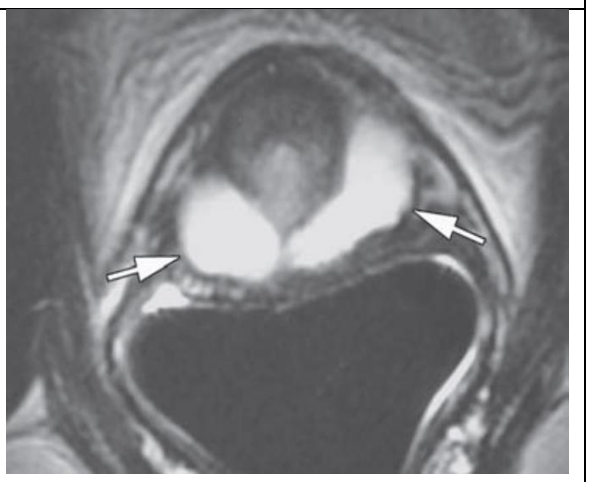
Clinical "Triad of Ds":

- Dysuria, Dyspareunia, and Postvoid dribbling.

Voiding Cystourethrogram:	**CT voiding Cystourethrogram:**
Multilocular diverticulum filled with contrast agent (arrows) at the level of the mid-urethra	Communication between urethral lumen and urethral diverticulum filled with contrast agent (arrow)
	

Shapes

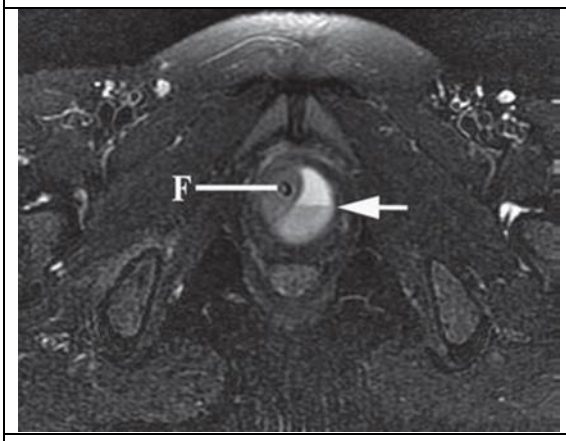
Simple	Horse-shoe or U-shaped	Circumferential
		

Unilocular	Multilocular
	

❖ Complications Of Urethral Diverticulum

a) Infected urethral diverticulum

T1 hyperintense signal
T2 fluid / fluid level

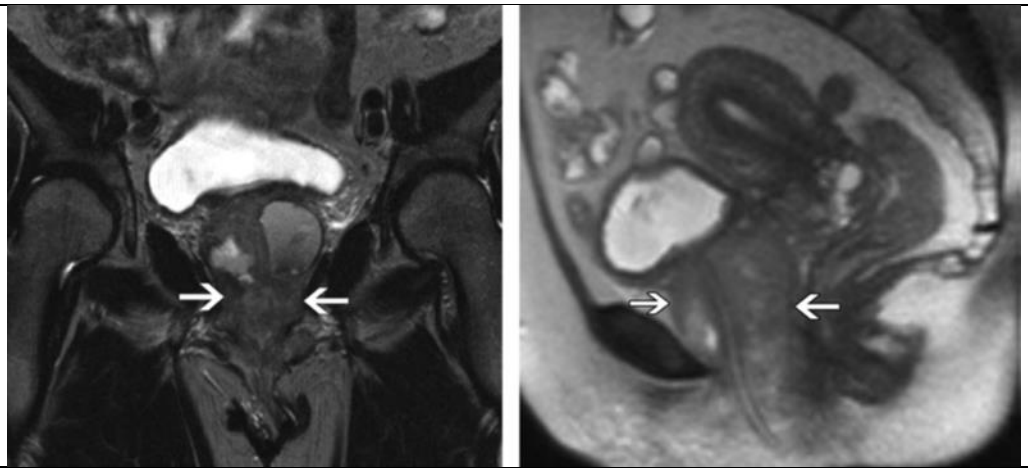


b) Calculus formation

occurs in up to 10% of patients
US: as a focus of echogenic shadowing within the urethral diverticulum.
Hypointense foci on both T1- and T2-

c) Malignancy

- To date, there have been fewer than 100 cases of malignancy developing in a urethral diverticulum.
- Although squamous cell carcinoma is the most common malignancy of the female urethra, the majority (60%) of tumors arising from urethral diverticula are adenocarcinomas

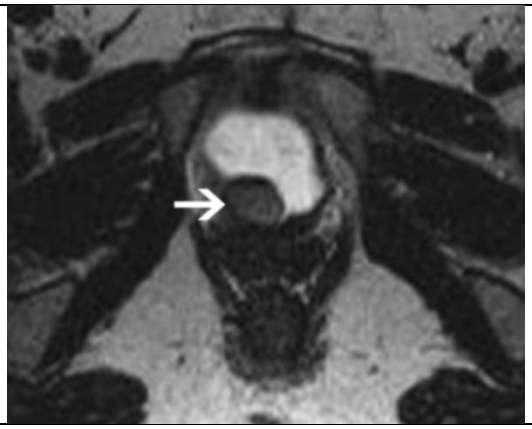


5) Endometrioma

- The presence of endometrial tissue in extrauterine sites, typically in the ovaries and peritoneal cavity.
- Implantation of endometrial tissue in the periurethral tissues may occur during surgical procedures
- Lesions are treated with complete surgical resection or removal by laser surgery and electrocautery

6) Periurethral collagen injections

- are used to treat stress incontinence in female patients.
- The collagen appears as hyperintense nodules in the wall of the urethra on T2
- may mimic periurethral cystic lesions or urethral diverticula



7) Müllerian Cyst

- are embryologic remnants of the müllerian (paramesonephric) duct
- that are lined with mucinous, pseudostratified columnar epithelium.
- They are located in the anterolateral vaginal wall
- Symptomatic cysts may require surgical excision.

8) Epidermal Inclusion Cyst

- Vaginal inclusion cysts, are located at sites of prior trauma or surgery and are lined with stratified squamous epithelium .
- Location: posterior or lateral vaginal walls are common sites of cyst formation.
- Marsupialization is used to treat symptomatic cysts.

Vaginal Cuff Disease

- Represents the apex of the vagina, where the apposed upper walls are sutured together at hysterectomy.

- For clinical management and screening, it is important to determine whether a cervical remnant is present, since surgical history is often unclear regarding total versus partial hysterectomy.

US:

- The normal vaginal cuff is generally small, symmetric, and homogeneously hypoechoic by US.
- The cervix is often well defined, especially at US, and may contain nabothian cysts

- ***MRI*** vaginal cuff and cervical remnant are well assessed at, which is generally superior to US and CT in terms of diagnostic quality.
- ***PET/CT*** can be performed to differentiate postoperative changes from cancer recurrence.

Vaginal Cuff Endometriosis:

- At pelvic US, a diagnosis of may be considered when a new, persistent, or recurrent vaginal cuff mass is seen,
- especially if the mass is echogenic (suggesting blood products)
- The patient has known endometriosis.
- A vaginal cuff endometrioma can be confirmed at MR imaging as a mass that is isointense relative to blood products

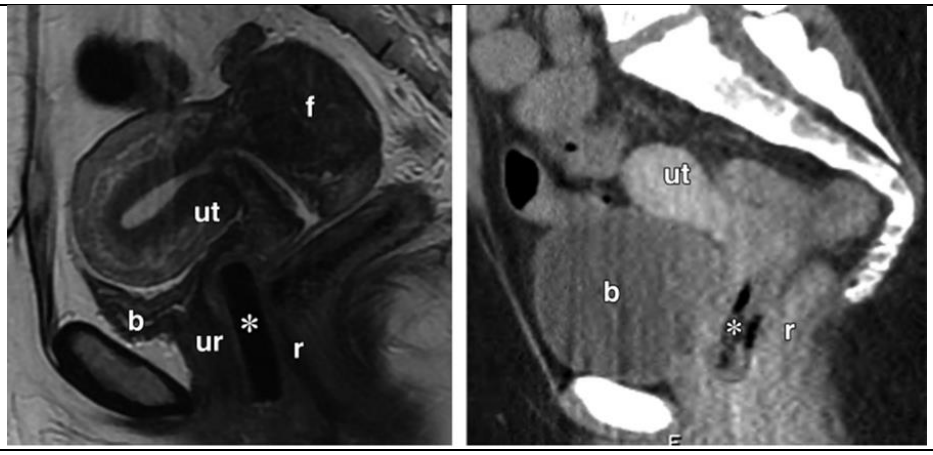
Vaginal Cuff Hematomas:

- Are typically identified at US in post-hysterectomy patients with bleeding.
- Hematomas can be difficult to distinguish from vaginal cuff abscesses at US and CT because air identified in these fluid collections may have a postoperative rather than an infectious etiology;
- Correlation with clinical symptoms and an elevated white blood cell count are usually diagnostic.
- MR imaging is generally indicated for evaluation of the posthysterectomy vaginal cuff.

Vaginal Foreign Bodies

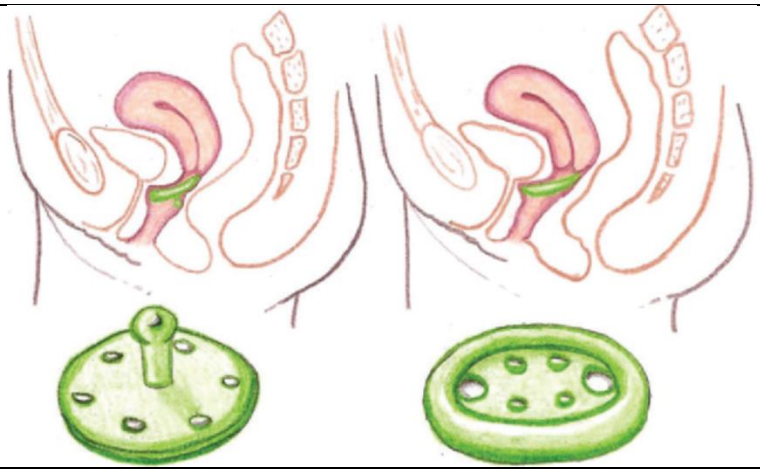
- Familiarity with the imaging characteristics of vaginal foreign bodies aids in the assessment of the vagina, thereby avoiding a misdiagnosis of pelvic disease
- Patients often inadvertently leave tampons in place during imaging examinations

❖Retained Tampon



❖Vaginal Pessary Devices

- are used for the treatment of uterine, vaginal, urinary bladder, and rectal prolapse & urinary incontinence,
- They come in a variety of sizes and shapes.
- should be removed before TVUS is attempted but can be left in place during transabdominal US, CT, or MR

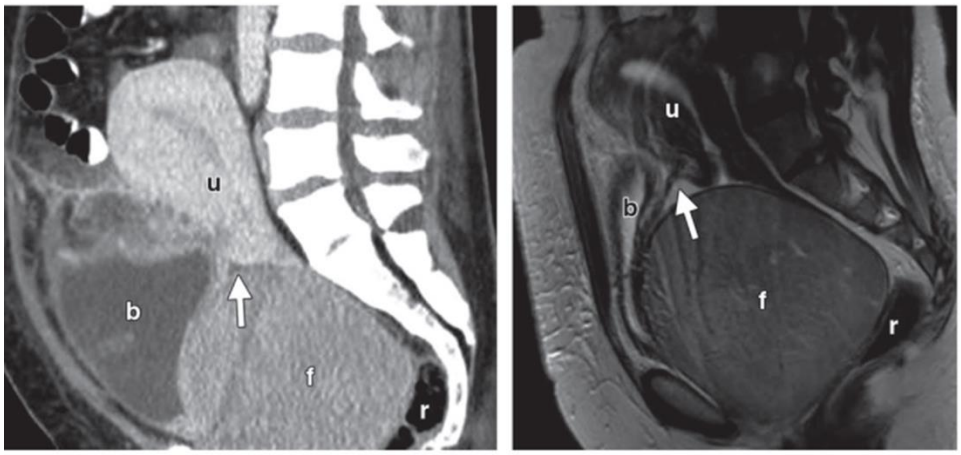


Vaginal Leiomyoma

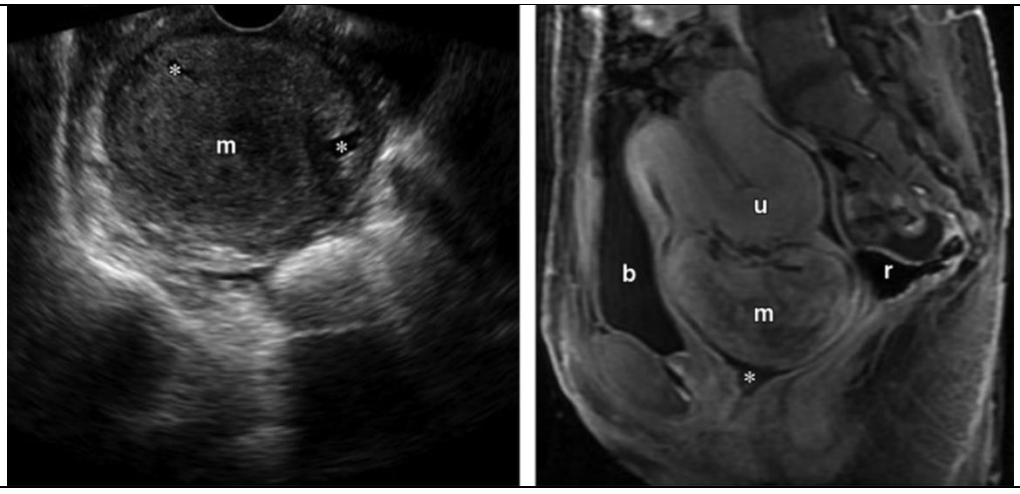
- are rare in the vagina
- May originate in the smooth muscle of the vagina, local arterial musculature, or smooth muscle of the bladder or urethra.

- Location :- more common at the anterior vaginal wall

- Imaging findings:
- Demonstrate characteristics similar to those of uterine leiomyomas



- **Inverted uterus + Fundal fibroid leading point for uterine inversion into the vaginal canal**



Primary Vaginal Malignancy

- Rare.
- Only 1%–2% of all gynecologic malignancies
- < 20% of vaginal malignancies
- Associated with human papilloma virus .
- Most tumors that are found at physical examination are small and do not require further imaging.

Histopathology:

❖ **Squamous cell carcinoma**

- Most common cancer of the vagina.
- 85%–87% of all 1ry vaginal malignancies

❖ **Non–squamous cell carcinomas**

- 15% of all primary vaginal carcinomas
- Adenocarcinoma (9%)
- Melanoma (3%)
- Sarcoma (3%)

FIGO Staging Classification for Vaginal Carcinoma

FIGO Stage	Description	TNM Category
0	Carcinoma in situ	Tis
I	Tumor confined to the vagina	T1
II	Tumor invades paravaginal tissues but not the pelvic sidewall	T2
III	Tumor extension to the pelvic sidewall	T3
IVA	Tumor extends beyond the true pelvis and invades the bladder, urethra, or rectum	T4
IVB	Distant metastases	M1

❖ Pattern of Growth:

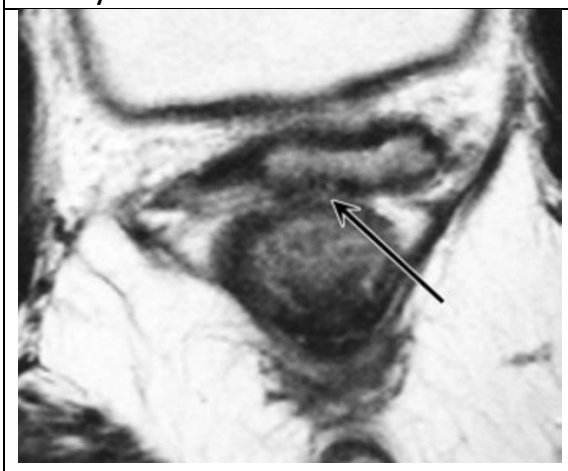
- Ulcerating pattern = ill-defined, irregular, diffuse mass
- Fungating pattern = Well-defined lobulated mass
- Annular pattern = circumferential thickening

❖ MR Signal:

- T1: isointense to muscle
- T2: homogeneous intermediate SI
  - higher than that of muscle
  - Lower than that of fat
  - can be appreciated as separate from the low signal intensity of the vaginal wall

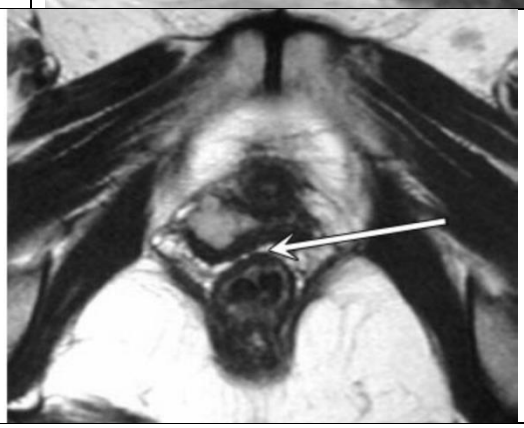
❖ Stage I tumors

- T2: A mass or plaque of tissue of intermediate signal intensity, expanding and filling the vagina
- Preservation of the low signal intensity of the outer vaginal muscularis layer.



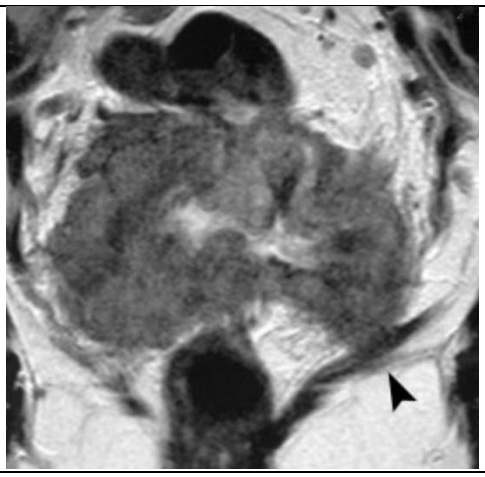
❖ Stage II

- Loss of the low signal intensity of the vaginal muscularis layer
- Tumor intermediate-signal extend through the low-signal-intensity rim of the vaginal muscularis and infiltrate the rectovaginal fat plane
- Not extending to the pelvic sidewall



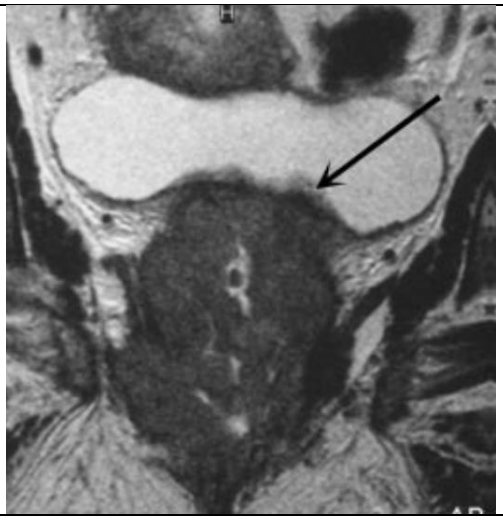
❖ Stage III

- Tumor extends laterally to the pelvic sidewall,
- T2: The low signal intensity of the sidewall muscle and pelvic floor contrasts with the intermediate signal intensity of the tumor



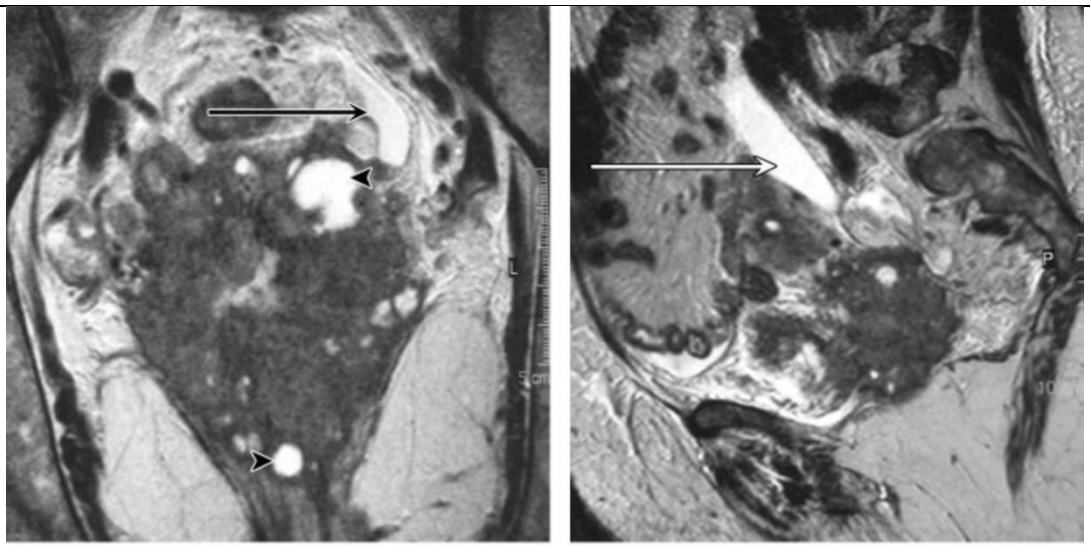
❖ Stage IVA

- Tumor invasion of the mucosa of the bladder or rectum.
- The presence of bullous edema is not sufficient evidence to classify a tumor as stage IVA.
- T2: Invasion through the low signal intensity of the bladder or rectal wall.
- Loss of the intervening vesicovaginal fat plane or the rectovaginal septum.



❖ Stage IVB

- Disease spreads beyond the pelvis and may involve the peritoneum and small or large bowel loops
- The most common sites of distant metastases are the lung, liver, and bone



Female Genital System

Perineum & Vulva

Female perineum:

- Diamond-shaped structure
- Inferior to the pelvic diaphragm
- Anteriorly: Symphysis pubis
- Posteriorly: coccyx.
- Anterolaterally: Ischiopubic rami and ischial tuberosities
- Posterolaterally: Sacrotuberous ligaments
- Contains:
    - Distal two-thirds of the urethra
    - Distal vagina at the level of the introitus
    - Anal canal.
- Divided into:
    - Anterior urogenital triangle
    - Posterior anal triangle

Vulva:

- Represents the external genitalia.

❖ DD of diseases:

A) Vulvar lesions:

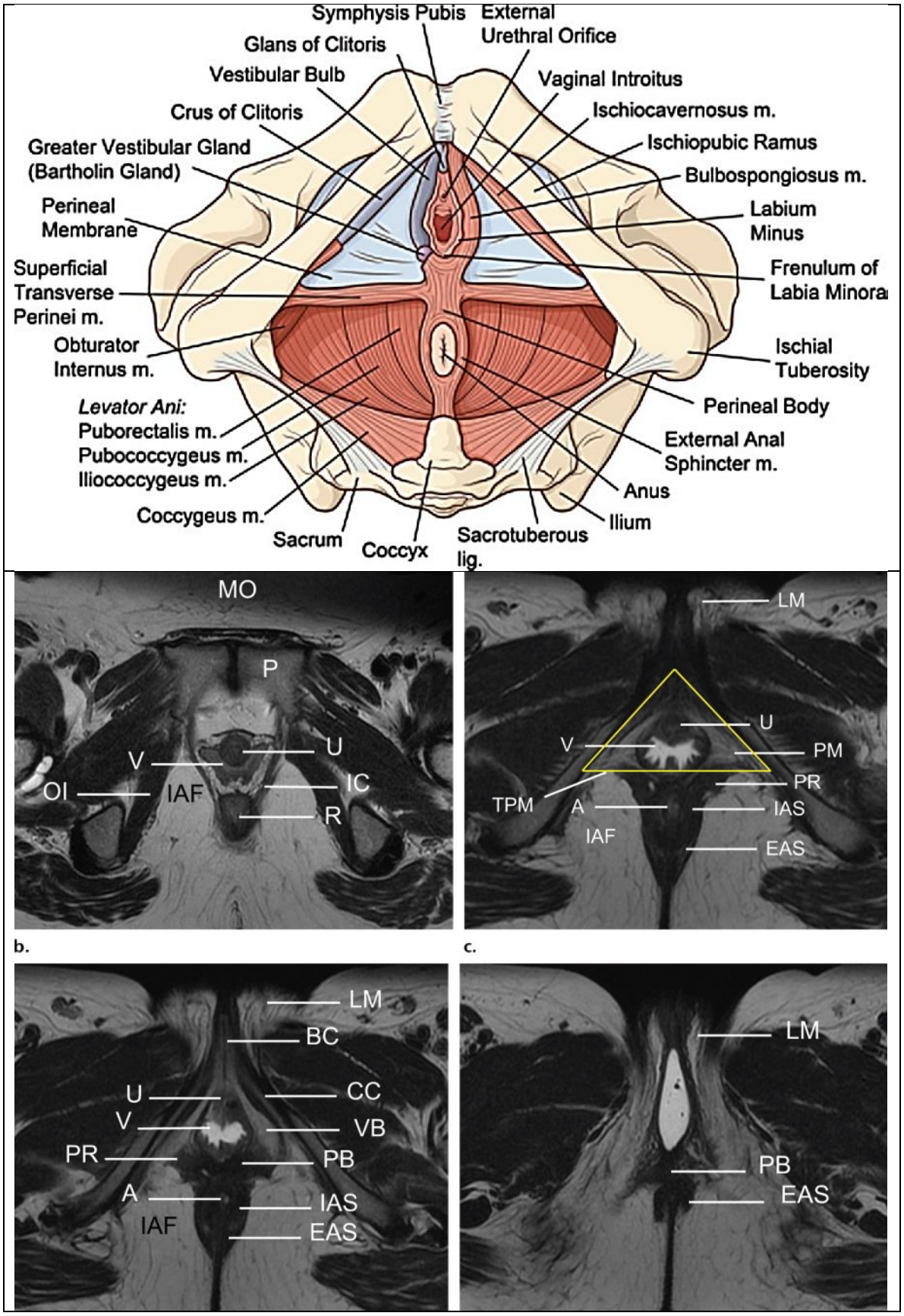
- Developmental
- Vascular lesions
- Trauma
- Infection (including Fournier gangrene)
- Thrombophlebitis
- Vaginal – uretheral cysts (discussed with vaginal section)
- Vulvar Tumors

B) Anal lesions:

- Anal fistula
- Ano-vaginal fistula
- Anal carcinoma

C) Musculoskeletal neoplasms:

- Mesenchymal neoplasms
- Lipomatous neoplasms
- Nerve sheath neoplasms
- Osseous neoplasms.


Symphysis Pubis
External Urethral Orifice
Glans of Clitoris
Vestibular Bulb
Vaginal Introitus
Crus of Clitoris
Ischiocavernosus m.
Greater Vestibular Gland (Bartholin Gland)
Ischiopubic Ramus
Bulbospongiosus m.
Perineal Membrane
Labium Minus
Superficial Transverse Perinei m.
Frenulum of Labia Minora
Obturator Internus m.
Ischial Tuberosity
Levator Ani:
Puborectalis m.
Pubococcygeus m.
Iliococcygeus m.
Perineal Body
External Anal Sphincter m.
Anus
Coccygeus m.
Ilium
Sacrum
Coccyx
Sacrotuberous lig.
MO
P
V
U
OI
IAF
IC
R
LM
U
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PM
PR
TPM
A
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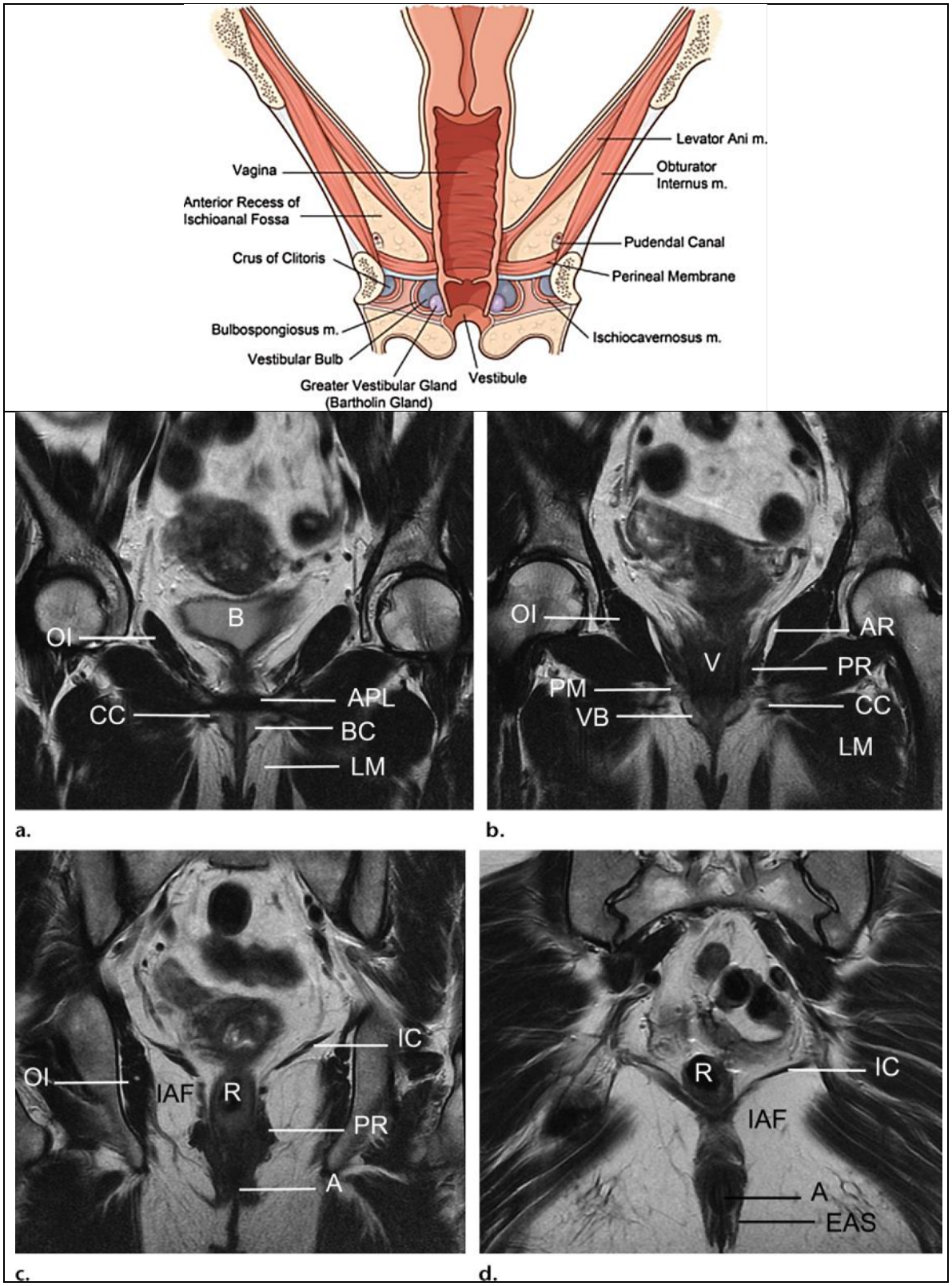
Levator Ani m.
Vagina
Obturator Internus m.
Anterior Recess of Ischioanal Fossa
Pudendal Canal
Crus of Clitoris
Perineal Membrane
Bulbospongiosus m.
Ischiocavernosus m.
Vestibular Bulb
Vestibule
Greater Vestibular Gland (Bartholin Gland)
OI
B
APL
CC
BC
LM
a.
OI
AR
V
PR
PM
CC
VB
LM
b.
IC
OI
IAF
R
PR
A
c.
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IC
IAF
A
EAS
d.

Vulvar Lesions

1) Hydrocele of the Canal of Nuck

- The round ligament is attached to the uterus, and a small protrusion of the parietal peritoneum accompanies the round ligament through the inguinal ring into the inguinal canal, corresponding to the processus vaginalis in males.
- Failure of obliteration results in either an indirect inguinal hernia or a hydrocele of the canal of Nuck, which can extend to the labium majus.

Clinical Picture:

- Fluctuating painless swelling in the inguinolabial region.

Location:

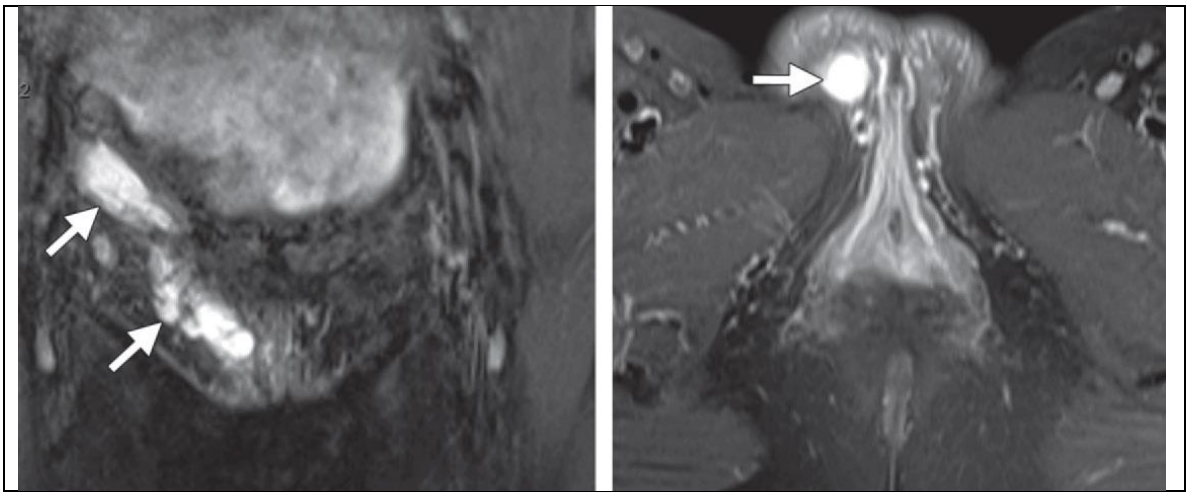
- Tubular structure extending into the right labium majus via the inguinal canal, along the course of the round ligament.

US

- First modality used for investigation.
- Tubular anechoic structure
- Comma shaped lesion with its tail directed toward the inguinal canal
- "cyst-within-a-cyst" depiction
- Graded compression with the transducer can display the canal extending from the abdominal cavity to the cyst.
- A Valsalva maneuver or coughing during real-time US can differentiate a hydrocele of the canal of Nuck from the more common inguinal hernia:
    - Hydrocele of the canal of Nuck => No content
    - Inguinal hernia => Intestinal contents or omentum

CT/MRI:

- Thin-walled cystic mass in the inguinolabial region
- CT: hypodense Fluid attenuation
- T2: High fluid signal

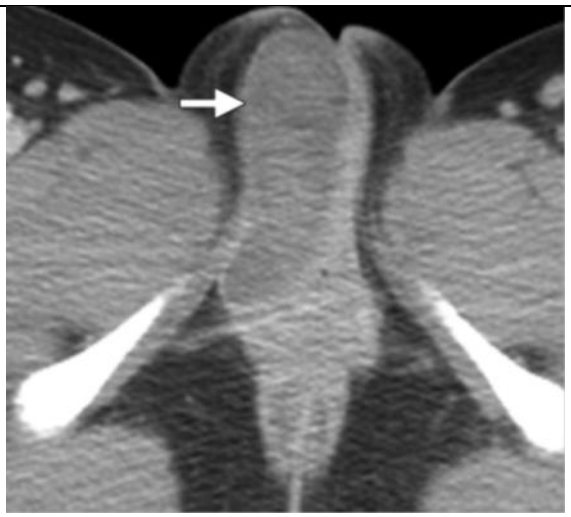


2) Trauma / Hematoma

- Nonobstetric accidental traumatic hematomas are relatively uncommon
- Accidental genital trauma is most commonly the result of straddle injuries (70%)

CT

- Mixed attenuation mass, representing hematoma
- Use of intravenous contrast material allows assessment for active extravasation.



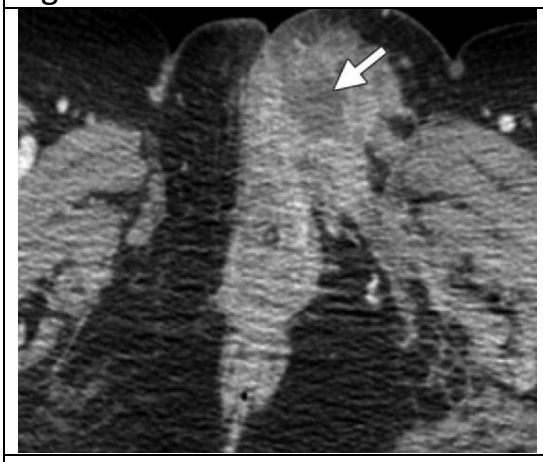
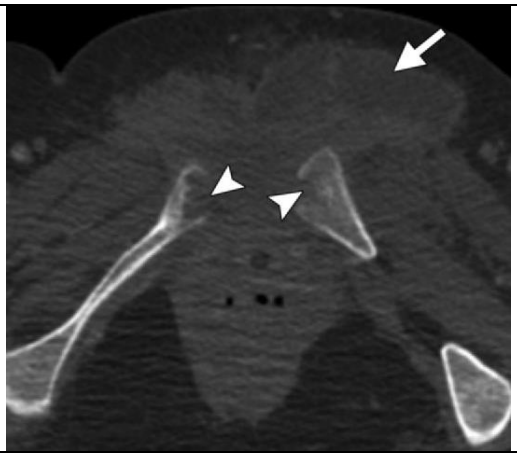
3) Vulvar Infection:

Risk factors

- Obesity and diabetes mellitus increasing the risk of skin and soft-tissue infections

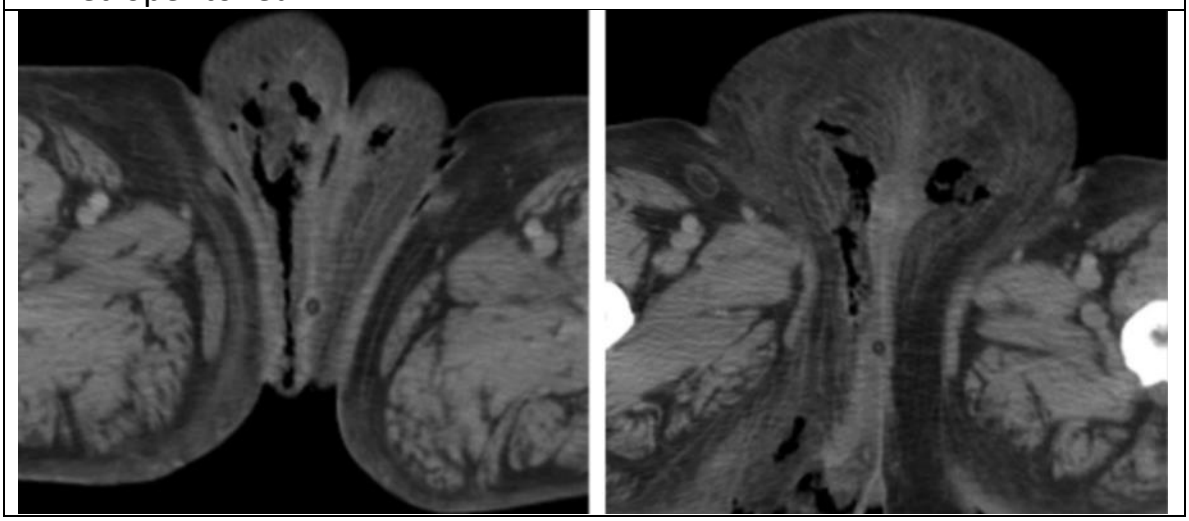
Causative Organism:

- Methicillin-resistant Staphylococcus aureus (MRSA) has been isolated in as many as 64% of patients with vulvar abscess

Rim-enhancing abscess (arrow) in the left labium majus, with significant inflammation.	osseous erosions (arrowheads), representing osteomyelitis
	

❖ *Fournier Gangrene*

- Soft-tissue thickening and inflammation.
- Subcutaneous gas can diffuse along fascial planes, extending from the perineum to the inguinal regions, thighs, body wall, and retroperitoneum



4) Labial Thrombophlebitis

Risk Factors:

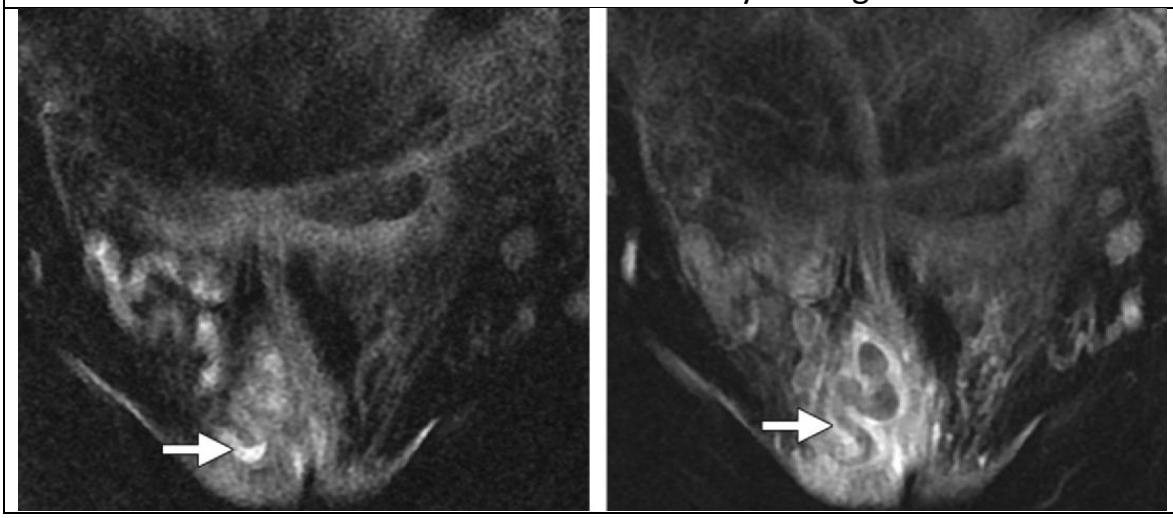
- Varicosities of the vulva have been described as a complication of pregnancy resulting from compression due to the gravid uterus, and usually shrink in the postpartum period.
- The use of tamoxifen in the treatment of breast cancer is associated with an increased risk of idiopathic venous thromboembolism

Color Doppler US:

- Dilated vessel with hypoechoic intraluminal filling defects
- Noncompressible vessel
- Absence of flow

MRI:

- Occluded dilated vessel with venous clots
- T1 hyperintense
- T2 hyperintense
- Perivascular inflammation is a useful ancillary finding



5) Vascular Lesions:

2 Main groups:

a) Hemangiomas: are true neoplasms characterized by:

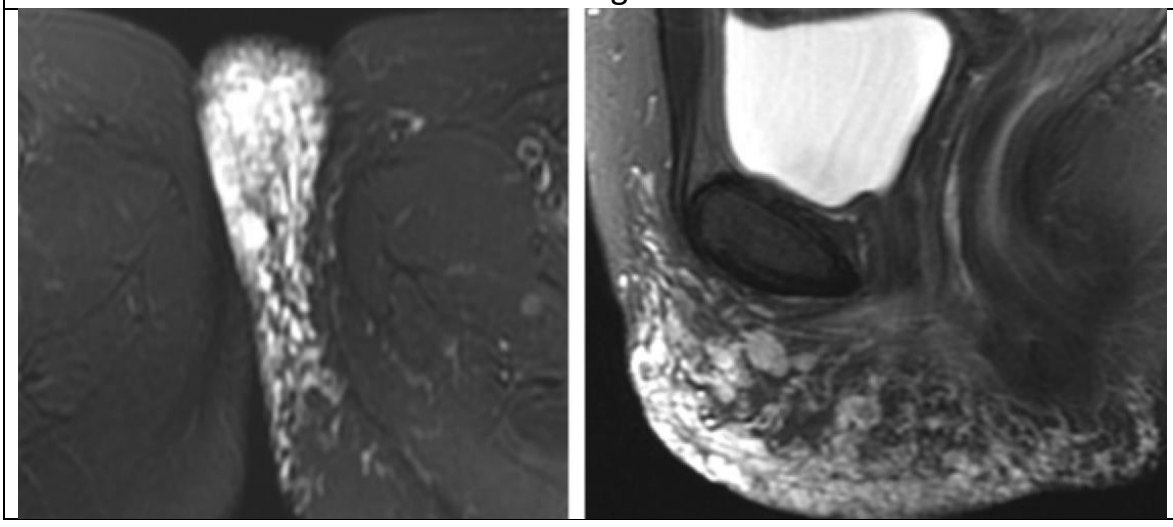
- Proliferative phase: Rapid postnatal growth
- Involuting phase: Slow regression during childhood

b) Vascular malformations:

- **Low flow:**
  - Capillary malformation
  - Lymphatic malformation
  - Venous malformation
  - Mixed malformation
- **High flow:**
  - Arteriovenous malformations (AVM)
  - Arteriovenous fistula (AVF)

❖ Labial Venolymphatic Malformation:

- Enlarging purple nontender left labial mass.
- T2: Cluster of hyperintense serpiginous tubular structures.
- +C: brisk enhancement of the vessels
- Phleboliths and calcification show signal voids



Vulvar Neoplasms

1) Primary Vulvar Carcinoma:

- Rare
- 4% of all gynecologic malignancies

Bimodal age distribution:

- Less than 20% < 50 years
- more than 50% > 70 years

Risk Factor:

- Human papilloma virus

Histopathology:

- ***Squamous cell carcinoma (85%)***
- Adenocarcinoma
- Sarcoma
- Basal cell cancer,
- Extramammary Paget disease

Location:

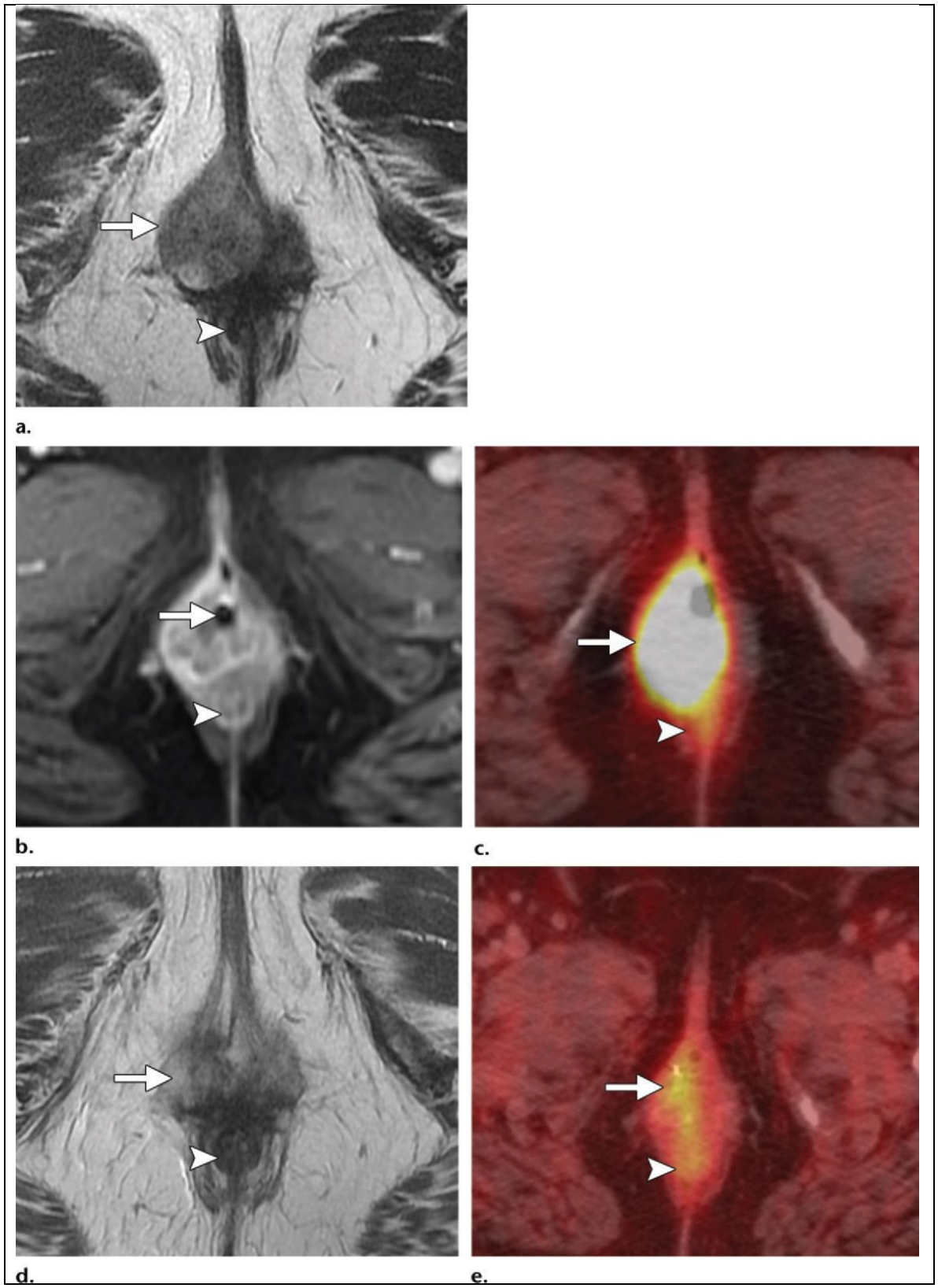
- Vulvar cancer involves the labia in two-thirds of cases
- Slow growing. Rarely does it extend beyond the pelvis.
- May extend to the urethra, anorectum, and vagina.

Prognostic factors:

- Tumor size
- depth of invasion
- Inguinofemoral lymph nodes
- Metastases

MRI Imaging Findings:

- T2: Tumor is intermediate in signal intensity
- +C: Variable enhancement


a.
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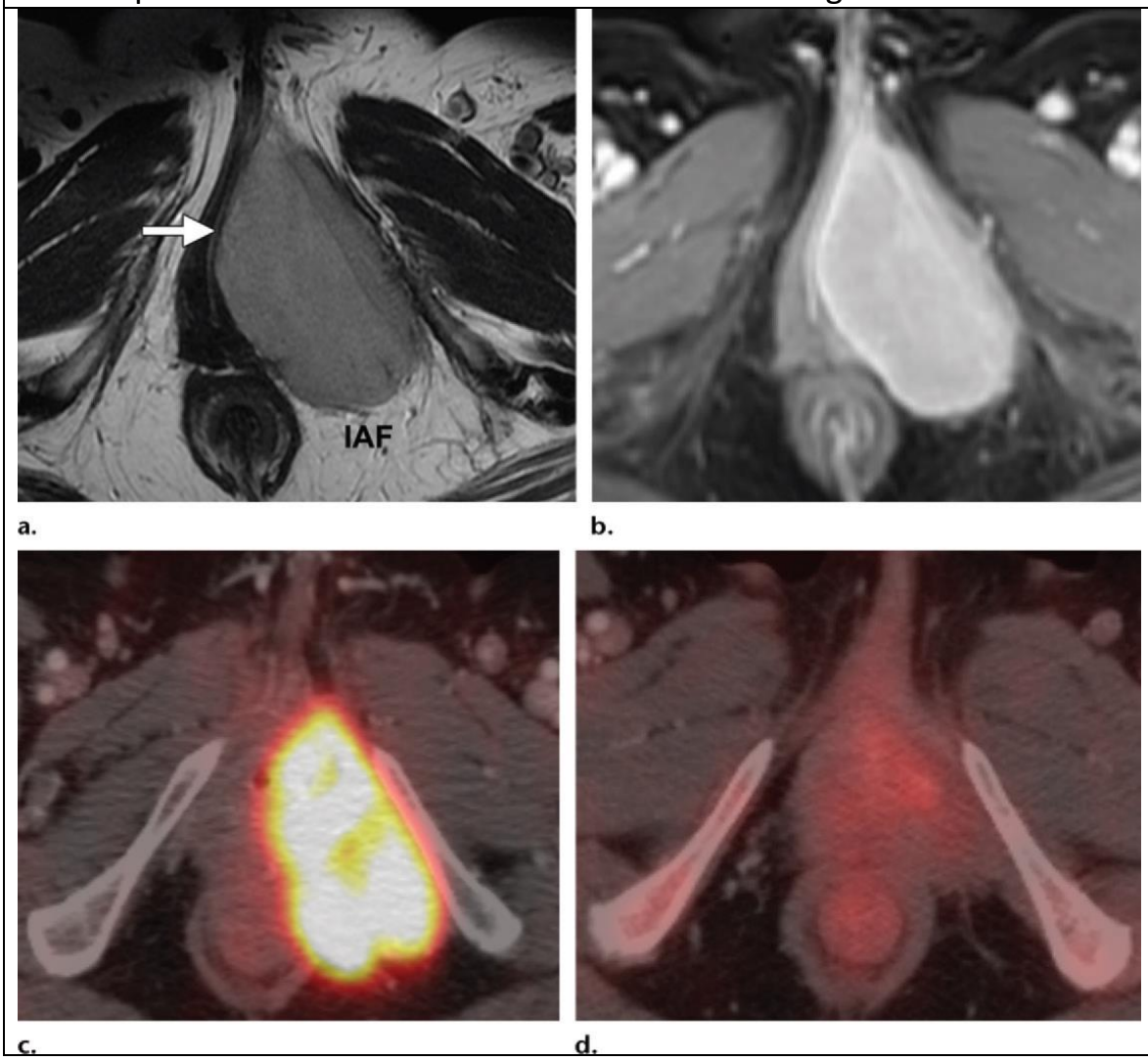
2) Vulvar Lymphoma:

- Primary or secondary non-Hodgkin lymphoma (NHL) involving the female genital tract is rare, most often occurring as a manifestation of systemic disease

Nonulcerated vulvar mass
Common location: labia majora being the predominant site
less frequent involvement of the clitoris and Bartholin gland.

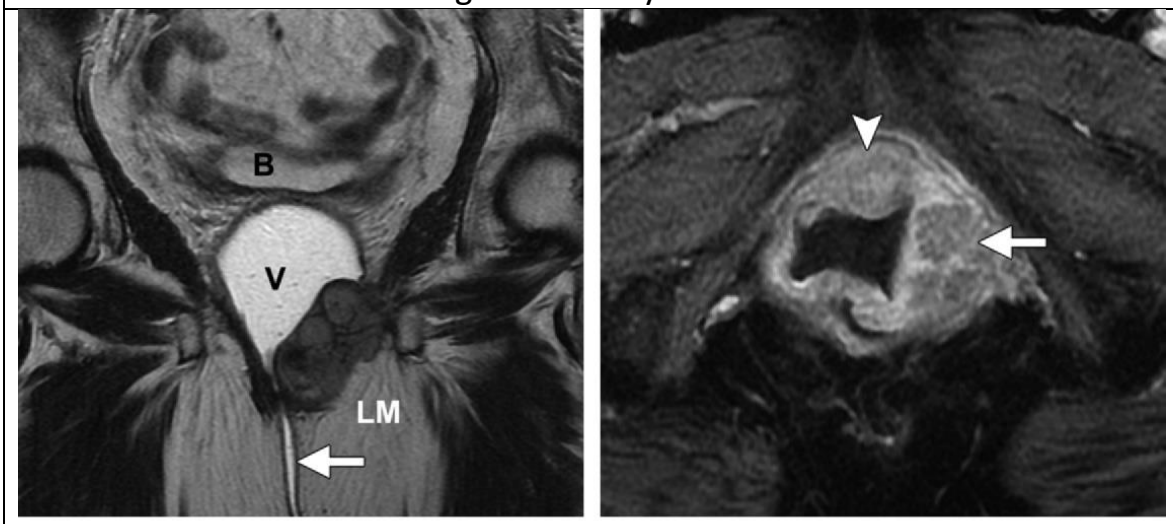


3) Vulvar Melanoma:

- Melanoma comprises 5% of all vulvar malignancies
- can be primary or metastatic.

Melanotic variety of melanoma

- T1: intermediate to high signal intensity
- T2: intermediate to low signal intensity



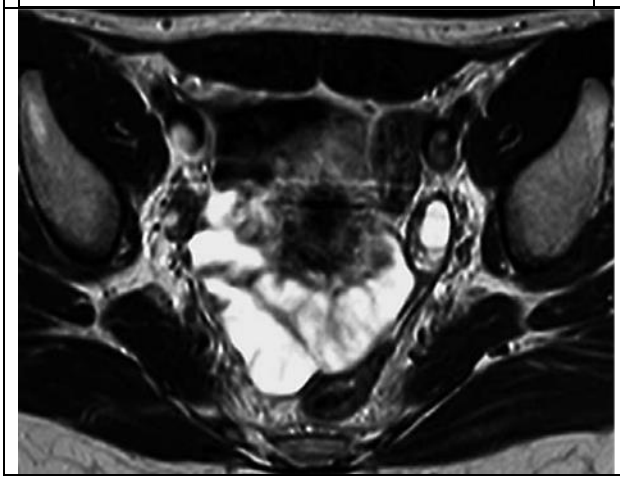
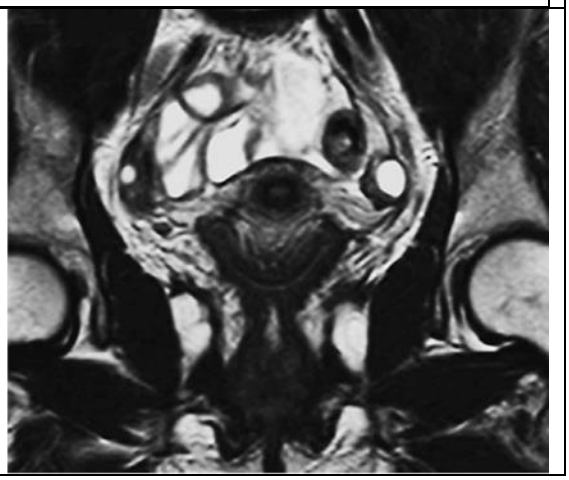
a. b.

Female Genital System

Ovary

Normal MRI Ovarian Anatomy

- Normal ovaries are demonstrated in ovarian fossa:
- Shallow peritoneal groove between external and internal iliac vessels.
- Ovoid shape
- Identified due to follicles which display very high signal on T2

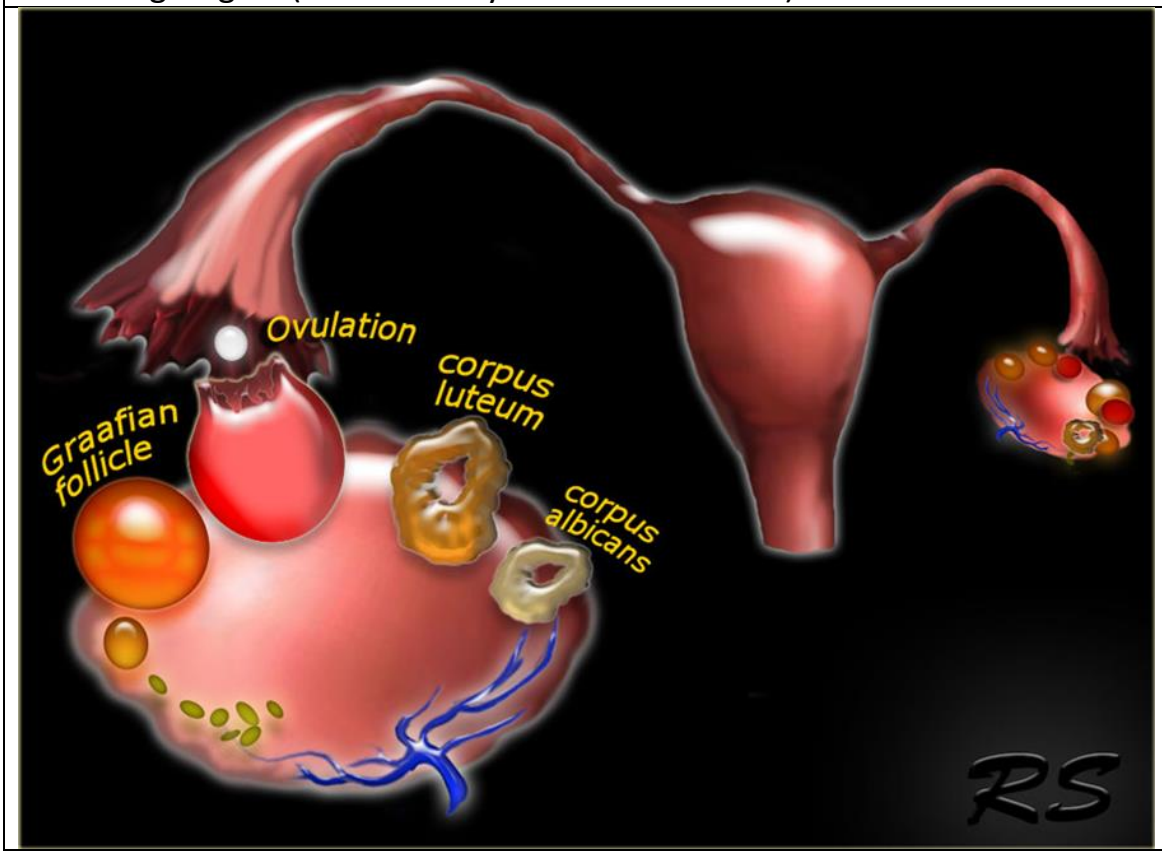
Axial T2	Coronal T2
	

Physiological Ovarian Cysts

❖ Premenopausal Women

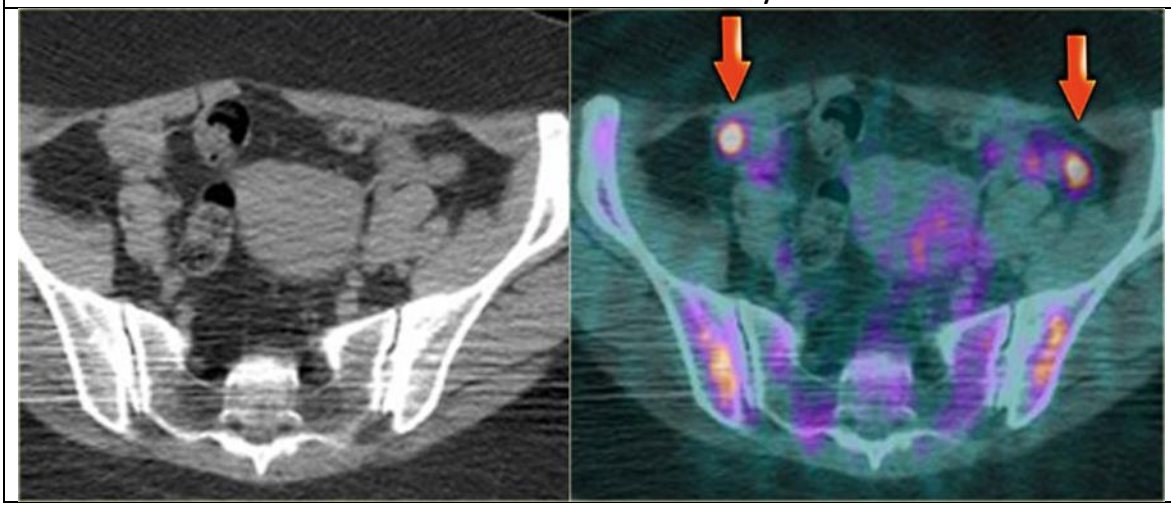
- The normal ovary contains over two million primary oocytes at birth, about 10 of which mature each menstrual cycle.
- Before Ovulation:
  - About 10 ovarian follicles that begin to mature
  - Only one becomes => Dominant follicle (Graafian follicle) => grows to a size of 18-25 mm by mid-cycle.
  - The other nine follicles become atretic and fibrous.
- After ovulation and release of the oocyte:
  - Dominant follicle => collapses => corpus luteum => degenerate => Corpus albicans.

- US: several anechoic, simple cysts consistent with Graafian follicles
- T2: high signal (as with many fluid filled entities)



FDG-PET pitfall - Normal Premenopausal Ovaries

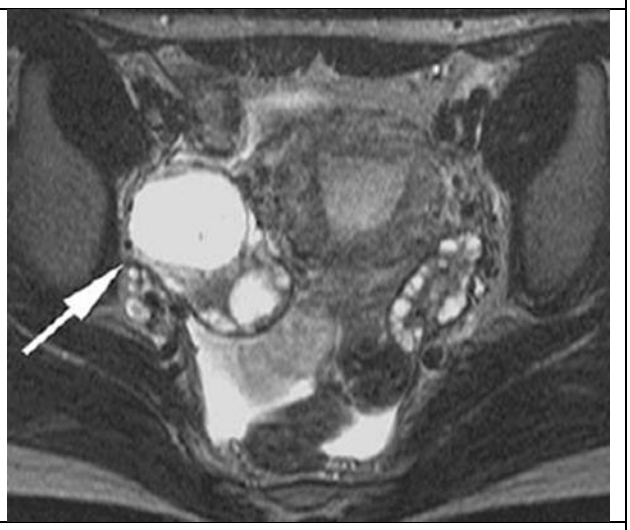
- In some pre-menopausal women the normal ovaries may be avidly PET positive, depending on the date in the menstrual cycle.
- Because in pre-menopausal women a PET-positive ovary may be either an adnexal neoplasm or completely normal, it is important to be aware of the possibility of physiologic mid-cycle FDG uptake and to correlate this finding with the clinical history.
- FDG-PET in pre-menopausal women should therefore preferably be scheduled in the first week of the menstrual cycle.



Functional Ovarian Cysts

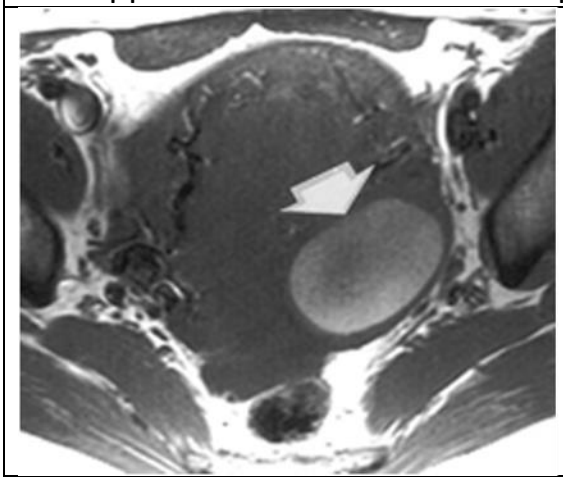
1) Follicular Cyst

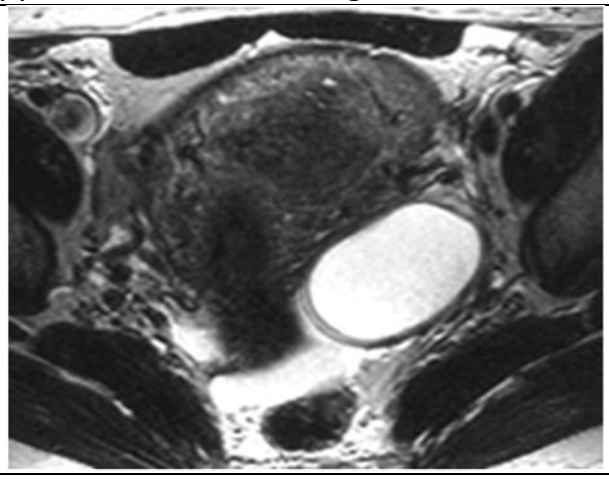
- A dominant Graafian follicle fails to ovulate and does not involute.
- Thin Wall Cyst With Clear Fluid
- Size 3-5cm
- Decrease in size after follow Up In 6 Weeks Duration or Following The Next Menses



2) Corpus Luteum Cyst

- After ovulation or during pregnancy corpus luteum may seal and fill with fluid or blood
- Irregular and thick walls
- Clear fluid/ hemorrhagic content
- Doppler: characteristic circular appearance is called 'ring of fire'.



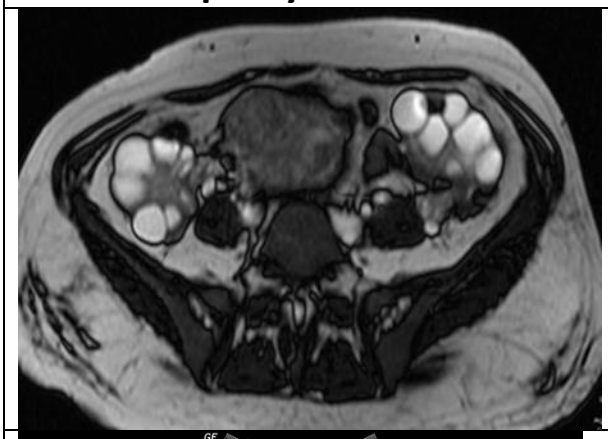
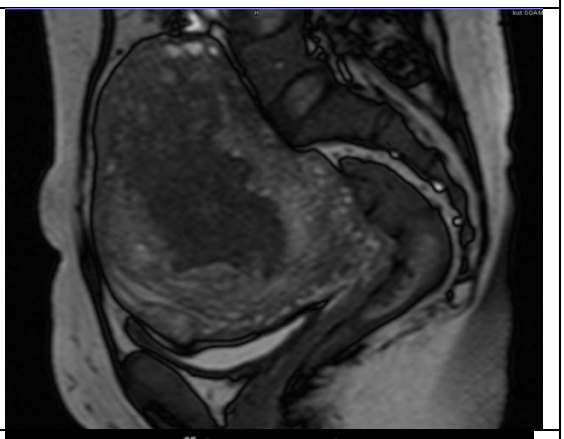
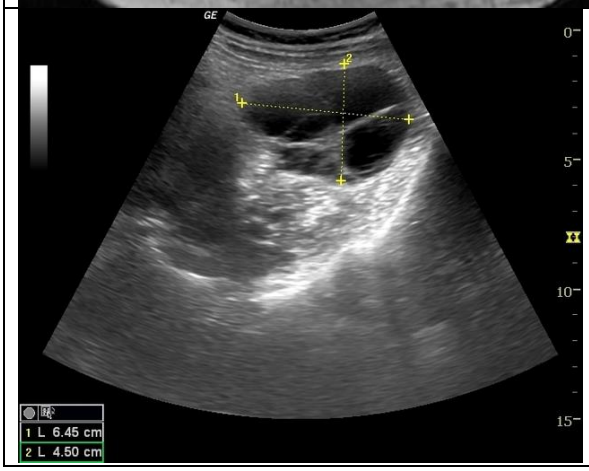


3) Theca Lutein Cyst

- Originate due to excessive amounts of circulating gonadotrophins such as beta-hCG.

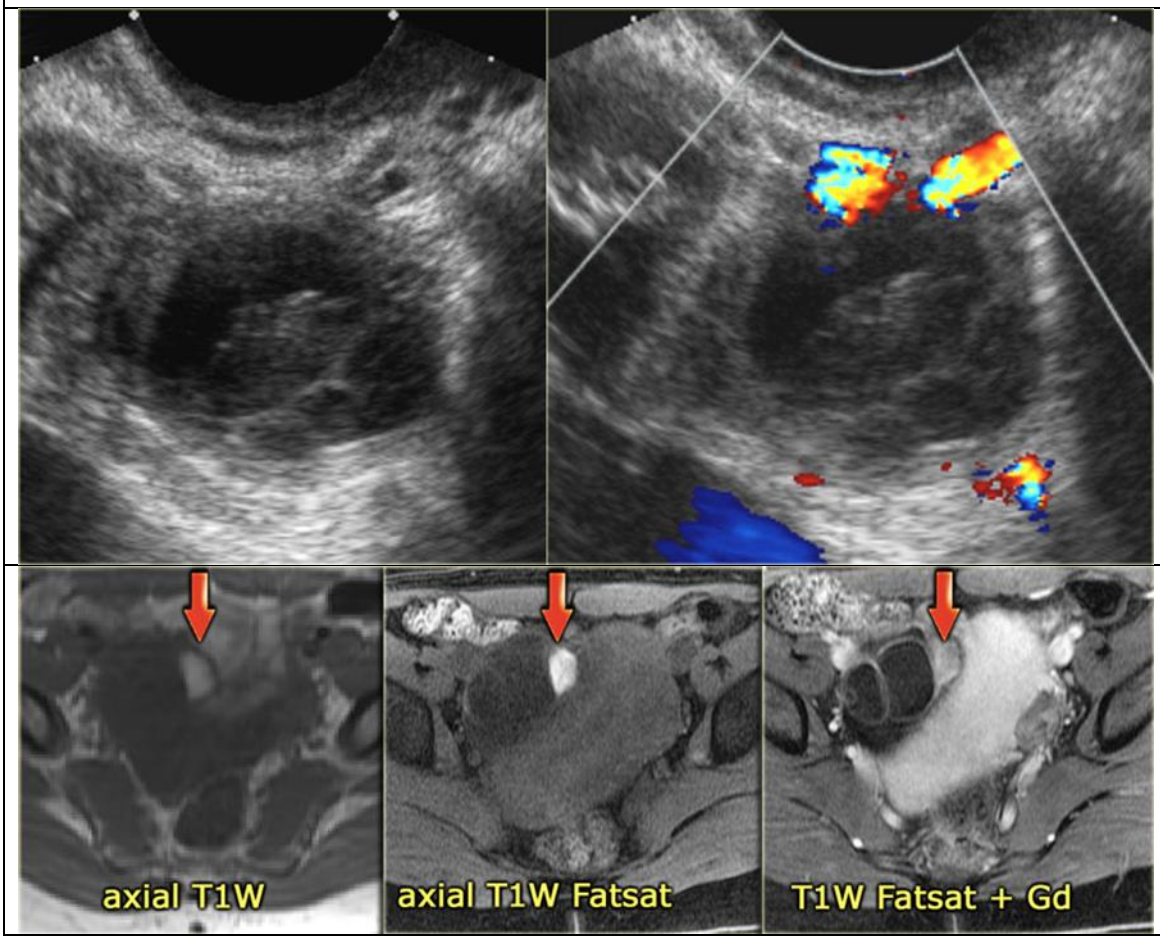
Associations

- Very high association with ***gestational trophoblastic disease***.
- Multifetal pregnancy
- Polycystic ovarian syndrome (PCOS)
- Diabetes mellitus
- Clomiphere intake
- Ovulation induction
- Rarely
    - Pregnancy with background chronic renal failure 2
    - Normal uncomplicated pregnancy

Bilateral ovarian enlargement with multiple cysts	**Hyadtiform invasive Mole**
	
	

4) Hemorrhagic Ovarian Cyst

- Result from hemorrhage into a corpus luteum or follicular cyst
- A unilocular thin-walled cyst with fibrin-strands or low-level echoes.
- Lace-like reticular echoes
- Clot may adhere to the cyst wall mimicking a nodule
- Doppler: No blood flow
- T1 Fat Sat: High signal
- T2: High signal
- +C: No enhancement



Polycystic Ovarian Syndrome (PCOS)

- is the most common endocrine abnormality in women of reproductive age.
- **1935, Stein and Leventhal were the first to describe a condition consisting of:**
  - **Amenorrhea**
  - **Obesity**
  - **Masculinizing symptoms**

❖ Health Consequences of PCOS

Infertility
Recurrent spontaneous abortion
Dyslipidemias
Hypertension
Type 2 diabetes mellitus
Coronary atherosclerosis
Cerebrovascular accidents
Endometrial carcinoma

❖ Insulin Resistance Syndrome = Syndrome X = Metabolic Syndrome

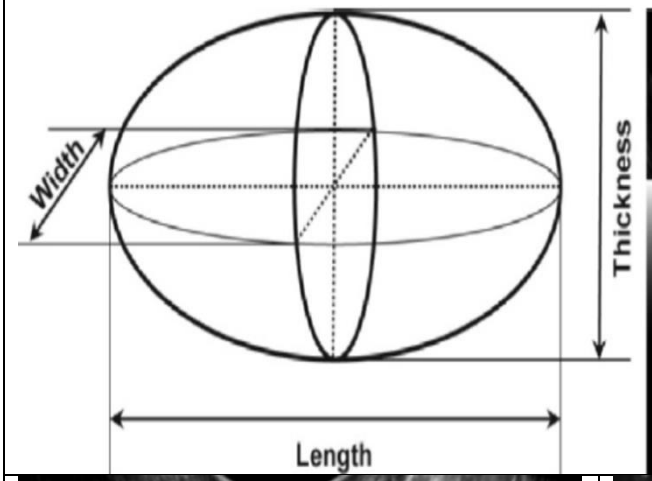
(a) Abdominal obesity (waist circumference >35 inches)
(b) Serum triglyceride level of > 150 mg/dL
(c) Serum HDL cholesterol level < 50 mg/dL
(d) Blood pressure > 130/85 mm Hg
(e) Serum fasting glucose level of > 100 mg/dL

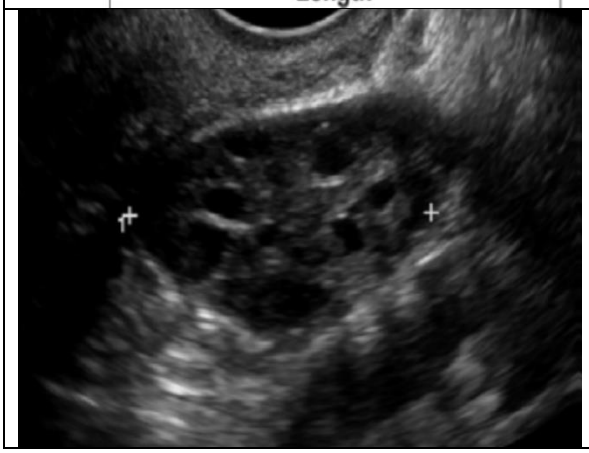
❖ PCOS Criteria:

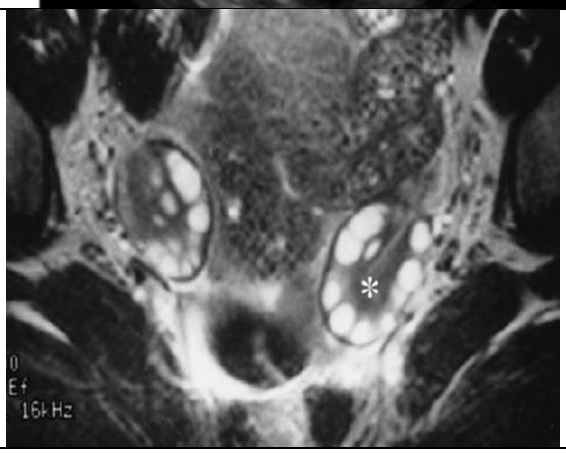
Clinical + biochemical + Sonographic grounds

The revised 2003 ASRM/ESHRE Rotterdam consensus criteria require two of the following three criteria for the diagnosis:

- **Hyperandrogenism (hirsutism or hyperandrogenemia)**
- **Ovarian dysfunction: Oligomenorrhea - Amenorrhea**
- **Polycystic ovaries:**
  - Ovarian volume > 10 cm3 (LenghtXWedthXHeightX0.5)
  - Peripheral location of follicles = String of pearls
  - Multiple follicles > 12 follicles
  - Small follicles measuring 2–9 mm in diameter.
  - Central stromal US hyperechoic + T2 hypointense







Ovarian Hyperstimulation Syndrome

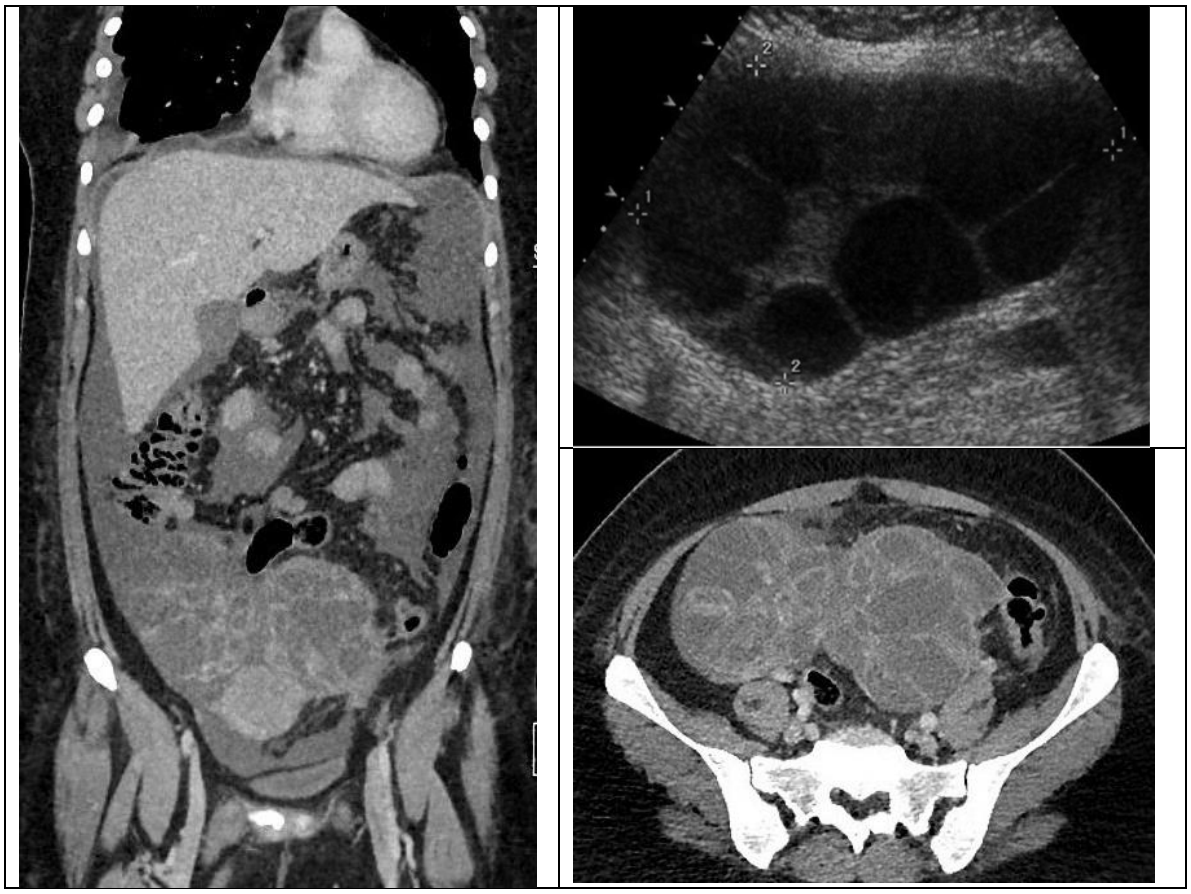
- is a complication of ovarian stimulation treatment (ovarian induction therapy) for in vitro fertilisation

Characterized by:

- ***Bilateral ovarian enlargement***
- ***Multiple large follicular cysts.***
- ***Fluid shift from intravascular space into 3rd space***
    - 3rd spacing
        - Ascites
        - Pleural effusion
        - ARDS
        - Intravascular hypovolemia
        - End-organ failure 2ry hypoperfusion
    - Hemoconcentration
        - Thromboembolic events
        - DIC

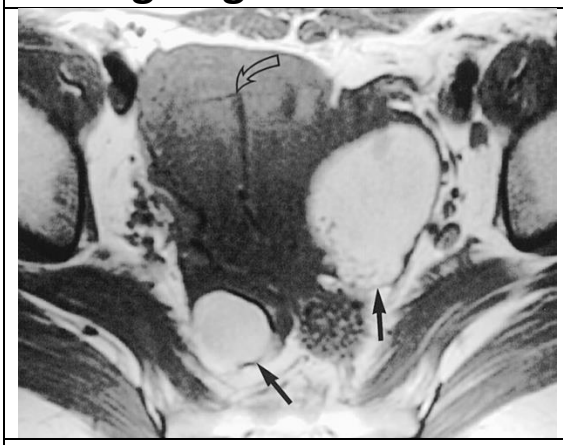
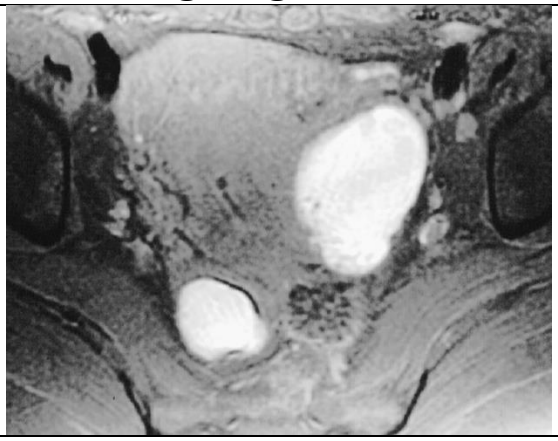
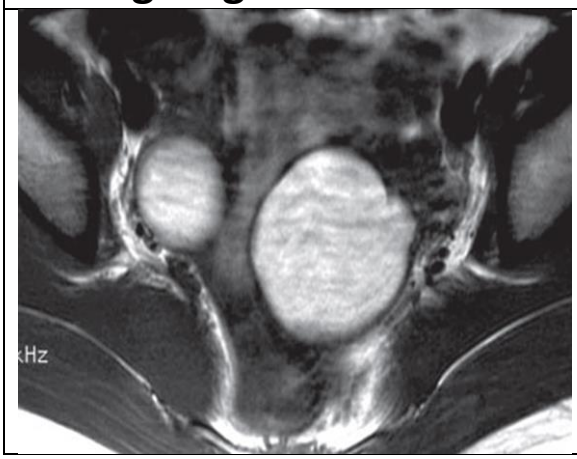
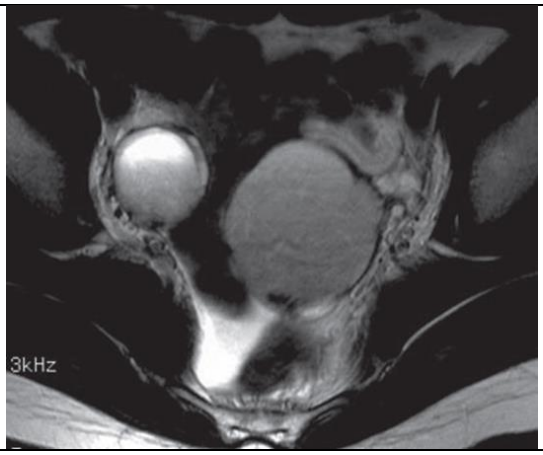
Modified Golan Classification Scheme for OHSS

Category	Ovarian Size (cm)	Grade	Signs and Symptoms
Mild	<6	I	Abdominal distention
		II	Abdominal distention, nausea, vomiting, diarrhea
Moderate	6–12	III	Abdominal distention, nausea, vomiting, diarrhea; ascites at US; weight gain
Severe	>12	IV	Ascites/hydrothorax
		V	Ascites/hydrothorax, hypovolemia, hemo-concentration, coagulation disorder, oliguria, shock



Endometrioma

- Ovarian cyst with Faint internal echoes
- Highly echogenic wall foci
- may be unilocular or multilocular.
- Thin or thick septations
- T1 & T1 FS: high SI
- T2: high or low signal (Shading)

T1: High signal	T1 FS: High signal
	
T1: High signal	**T2 low signal (shading)**
	

Ovarian Torsion

- Ovarian torsion is caused by partial or complete rotation of the ovarian vascular pedicle.
- The right ovary is more likely to twist than the left, suggesting that the sigmoid colon may help to prevent torsion

Predisposing Factors:

1) Pregnancy: 25% of adnexal torsions occur in pregnant patients. Adnexal torsion most commonly occurs between 6 - 14 weeks.
2) Developmental abnormalities: In young patients; such as long fallopian tubes or an absent mesosalpinx
3) Ovulation induction: have the highest incidence because of the development of numerous theca lutein cysts, which can massively enlarge the ovaries.
4) Enlargement of the ovary: secondary to a corpus luteal cyst or incidental benign ovarian neoplasm, most commonly a mature mature cystic teratomas or cystademoma, also can predispose to ovarian torsion

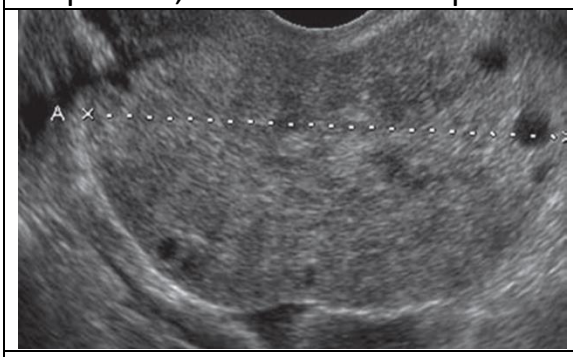
US Findings:

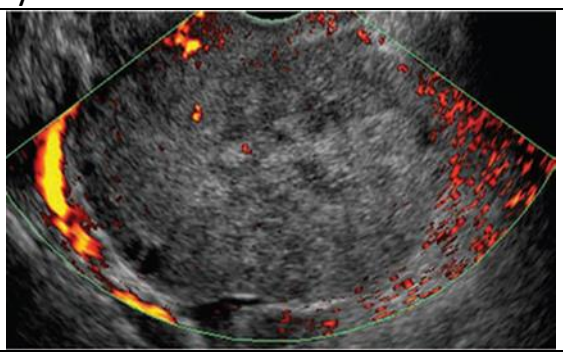
- Unilateral ovarian enlargement (>4 cm).
- Volume of the twisted ovary averages 28 times the normal size.
- Central: The ovarian stroma may be heterogeneous due to hemorrhage (hyperechoic) and edema (hypoechoic).
- Peripheral: Multiple small (up to 25 mm), uniform cysts: This appearance is likely secondary to follicles that have been displaced to the periphery due to the marked edema and venous congestion
- Free pelvic fluid in the cul-de-sac has been detected with US in up to 87% of cases of ovarian torsion

- Complex adnexal mass, which can be predominantly cystic, solid, or both.
- The Common cysts found in torsion include serous cystadenoma and hemorrhagic cyst
- The most common tumor predisposed for ovarian torsion is the benign mature cystic teratoma.

Color Doppler Findings

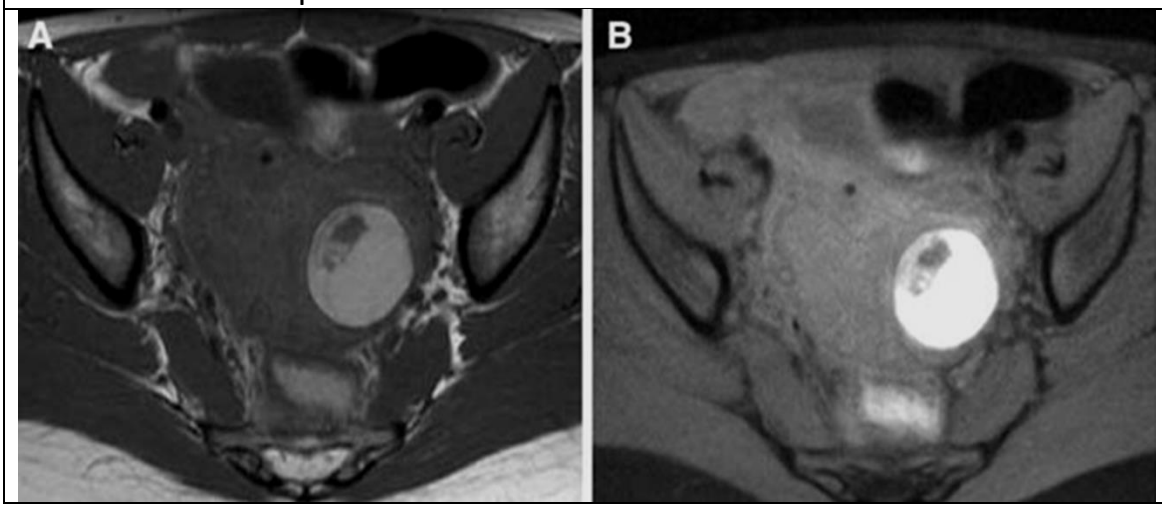
- Normal
- Loss of venous flow
- Loss of diastolic arterial flow
- Absence of flow
- Twisted vascular pedicle
- Whirl pool sign: Sometimes when tracking down the ovarian vascular pedicle, a coiled vascular pedicle may be seen.





MR findings in hemorrhagic infarction

- Lack of enhancement
- Engorged vessels surrounding the lesion
- A mass with high SI on T1 and T2 WI due to hemorrhage.
- Enlarged ovary may show low SI on T2WI due to interstitial hemorrhage
- Deviation of the uterus to the twisted side
- Ascites
- Obliteration of pelvic fat.



Ovarian Neoplasms

A. Germ cell tumors

B. Sex cord stromal tumors

C. Epithelial tumors

D. Metastatic

E. Lymphoma

- **2nd most common gynecological cancer**
- **5th most common female cancer**
- **5th most common cancer death in women**

- **In pediatric: ovarian germ cell tumor is the most common.**
- **In adults: ovarian epithelial tumor is the most common.**

- **90% of ovarian cancers are sporadic**
- **10% are inherited familial syndromes**

❖ Risk factors:

- Family history of ovarian cancer.
- BRCA1 and BRCA2 genes have a predisposition to develop ovarian and breast cancer with autosomal dominant transmission.

❖ Clinical Manifestations:

- Non-specific symptoms:
  - Abdominal pain is the most common presenting symptom (57%)
  - Palpable abdominal or pelvic mass (46%)
  - Nausea, vomiting, poor appetite, weight loss, constipation
  - Urinary frequency
- Asymptomatic, with the tumor being detected incidentally.
- Endocrine abnormalities can be the initial manifestation of hormone-producing ovarian tumors, depending on the patient's age:
  - Premenarcheal girls: symptoms of isosexual precocious puberty, including breast enlargement, abnormal vaginal bleeding, and development of pubic and axillary hair.
  - Adolescent girls: Menstrual irregularity demonstrated by hypermenorrhea or amenorrhea.

❖ Diagnostic Workup

- **Transabdominal US**
- **Endovaginal US**
- **CT**
- **MRI**

❖ Tumor Marker

- Elevated serum tumor marker levels may serve as an adjunct in:
  - ***Initial diagnosis***
  - ***Therapy monitoring***
  - ***Posttreatment surveillance***

i) Alpha-fetoprotein and b-hCG

- Elevated a-fetoprotein or b-hCG levels are virtually diagnostic of ovarian malignant germ cell tumors and should be measured in all young women who present with a pelvic mass
- The serum AFP level is elevated in patients with GCTs such as yolk sac tumors, immature teratomas, embryonal carcinomas.
- The serum marker b-hCG is mainly associated with choriocarcinoma
- The LDH level may occasionally be elevated in dysgerminoma

ii) Serum CA-125 Assay

- Serum CA-125 assay is a useful preoperative test for prediction of epithelial ovarian cancer

<u>CA-125 is not a tumor-specific antigen:</u>

- it is elevated in approximately 1% of healthy control subjects,
- Liver cirrhosis, endometriosis, first trimester pregnancy, pelvic inflammatory disease, and pancreatitis,
- 40% of patients with advanced intraabdominal nonovarian malignancy

Tumor Marker	Associated Ovarian Tumors
AFP	Yolk sac tumor Immature teratoma Embryonal carcinoma Sertoli-Leydig cell tumor (rare)
β-hCG	Choriocarcinoma Embryonal carcinoma Dysgerminoma (rare)
LDH	Dysgerminoma
CA-125	Epithelial tumors
Inhibin	Granulosa cell tumor

A- Ovarian Germ Cell Tumors

	Malignant Epithelial Tumors	Malignant Germ Cell Tumor
Prevalence	More common	Less common
Age	Older women >50y	Girls and young women
Race	More common in white women	More common in black and Asian women
Bilaterally	Serous 57.5% Mucinous 21.3% Endometrioid tumor 26.8% Clear cell 13.3%	Bilateral 4.3%
Tumor marker	**CA-125**	**AFP and B-HCG and LDH**
Endocrine manifestations	No	May result in hormonal production
5-year survival rate	44%, depend on tumor stage	100% for dysgerminoma 85% for other tumors

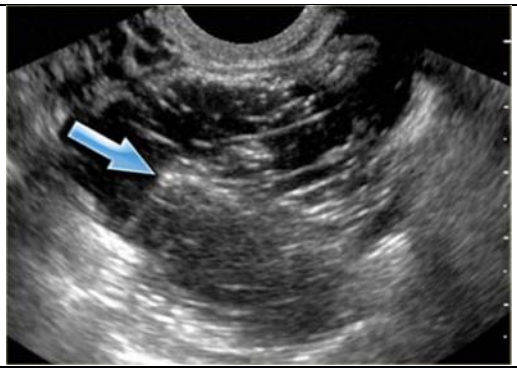
• Ovarian malignant germ cell tumors are heterogeneous tumors that are derived from the primitive germ cells of the embryonic gonad.
• 5% of germ cell tumors are malignant • 95% of germ cell tumors are being benign mature cystic teratomas • Ovarian malignant germ cell tumors are rare (2.6%) of all ovarian malignancies
• Age: Typically manifest in adolescence (first 2 decades of life)
• Clinical picture: Abdominal pain, palpable mass, and elevated serum tumor marker levels
• Usually, unilateral • may be bilateral in about 4.3% of patients
• Treatment: Chemosensitive and fertility-sparing surgery is the standard of care

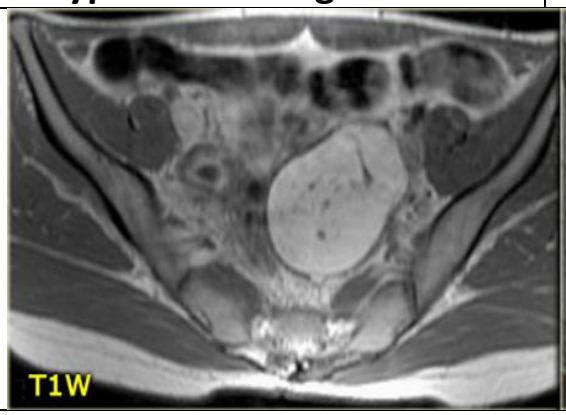
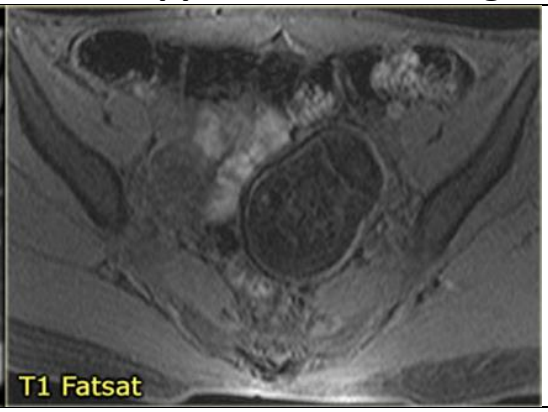
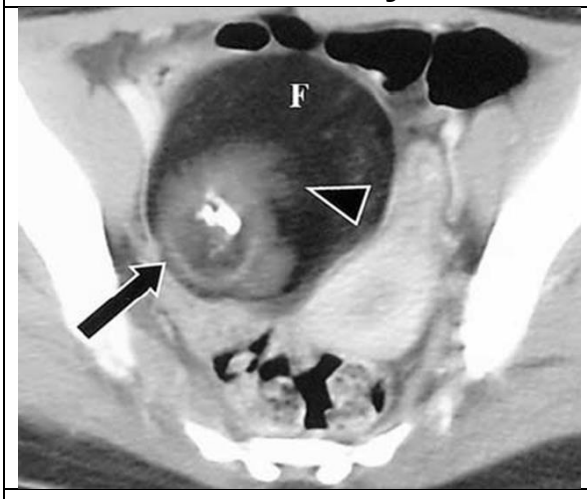
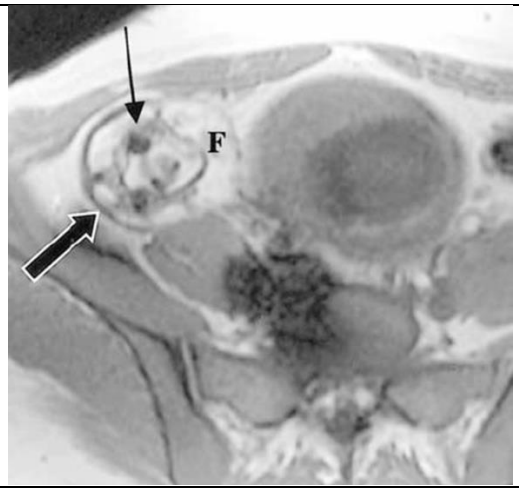
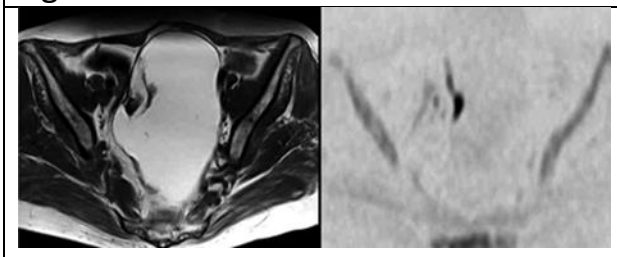
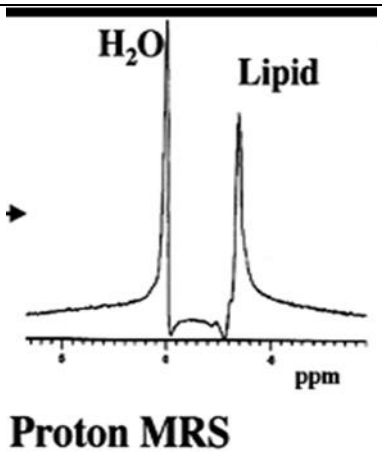
1) Mature Cystic Teratoma (Dermoid Cyst)

- ***Most common benign ovarian neoplasm***

- Young women of child-bearing age (between 20 and 40 years of age)
- Bilateral in ~15%

- Composed of well-differentiated tissues that derive from all three germ-cell layers (ectoderm, mesoderm, and endoderm)

Tip of iceberg sign: Acoustic shadowing from the hyperechoic part of the dermoid cyst	**Rokitansky nodule or dermoid plug:** Cystic mass, with hyperechoic solid mural nodule
	
Fat-fluid level: caused by fat floating on more aqueous fluid.	Multiple thin, echogenic lines or stripes: caused by hair floating in the cyst cavity.

T1: Hyperintense signal	T1 FS: suppression of the signal
	
Rokitansky nodule or dermoid plug contain: ***Hair – Teeth - Calcifications***	
	
DWI: Rokitansky Nodule Very strong signal DWI	MRS: Lipid peak in dermoid cyst
	

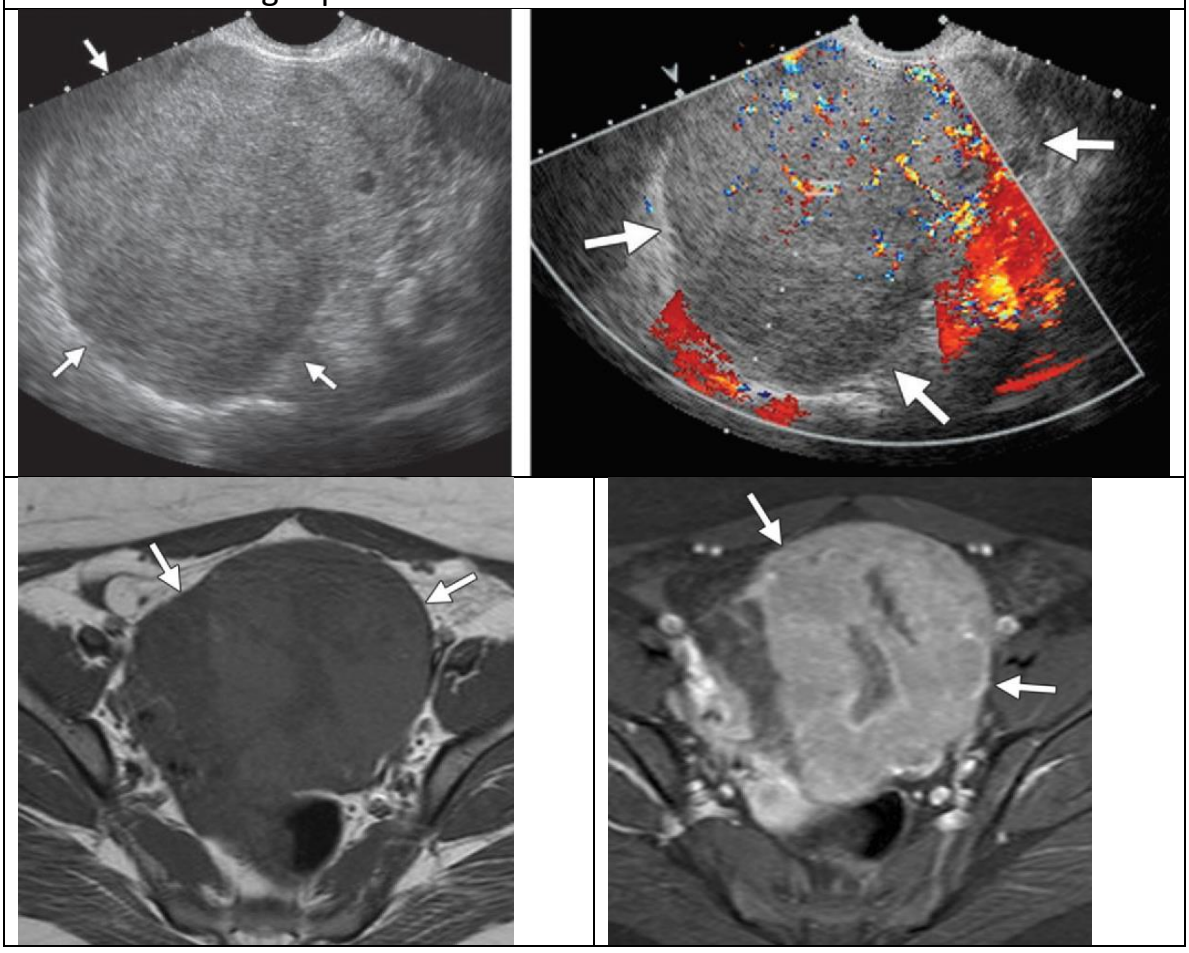
2) Dysgerminoma

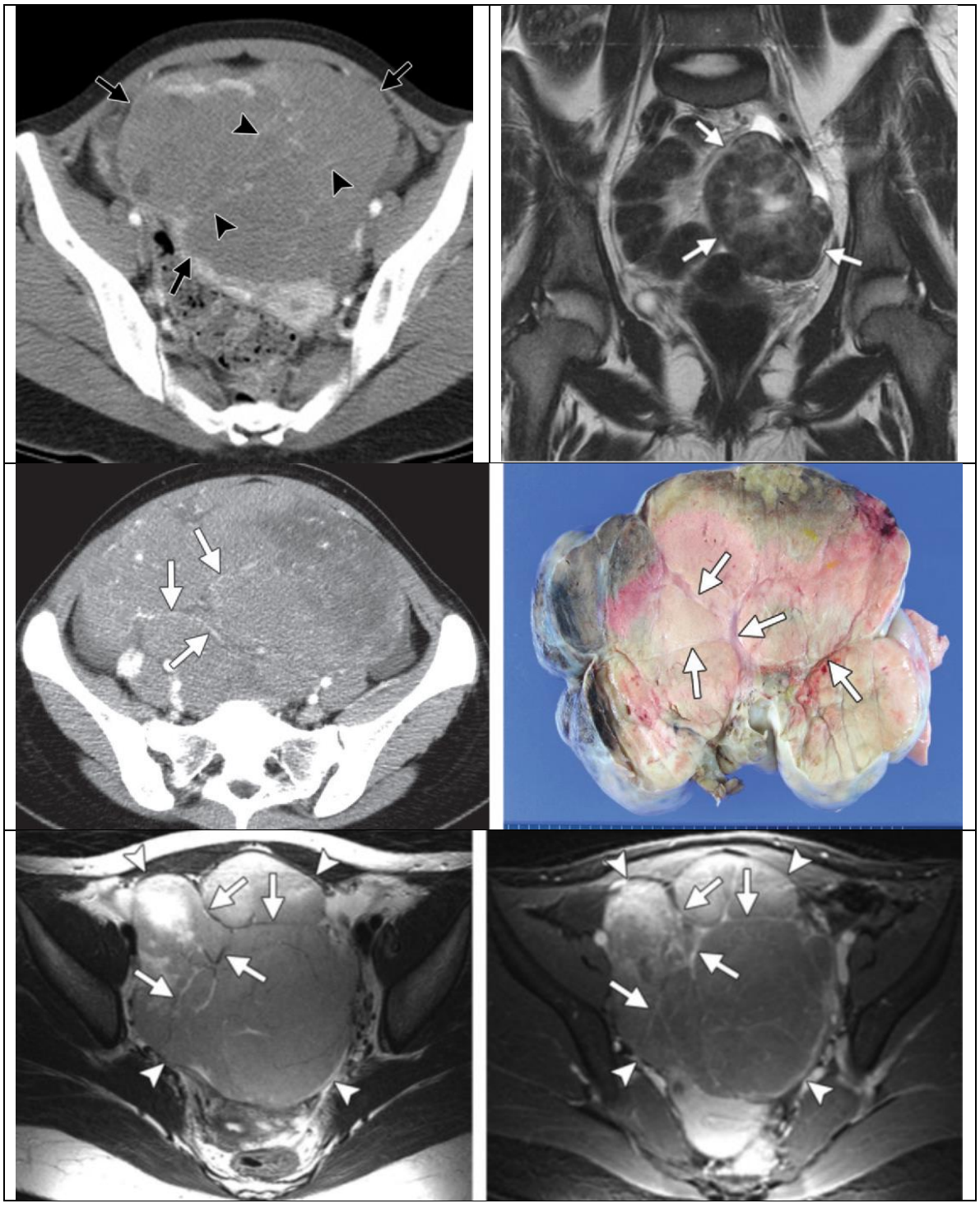
- Dysgerminoma is the ovarian counterpart to testicular seminoma.
- ***Most common ovarian malignant germ cell tumor***
- 1%–2% of primary ovarian neoplasms
- 32.8%–37.5% of malignant ovarian germ cell tumor

- **Age: Adolescence and early adulthood**
- **Tumor marker: Pure dysgerminomas do not secrete hormones**

Imaging findings:

- Well-defined predominant multilobulated solid lesion
- Divided into lobules by septae
- Smooth lobulated contours
- CT: Calcifications may be present in a speckled pattern
- T1: Low signal
- T2: Iso to slight hyperintese signal
- +C: Enhancing septations





3) Immature Teratoma

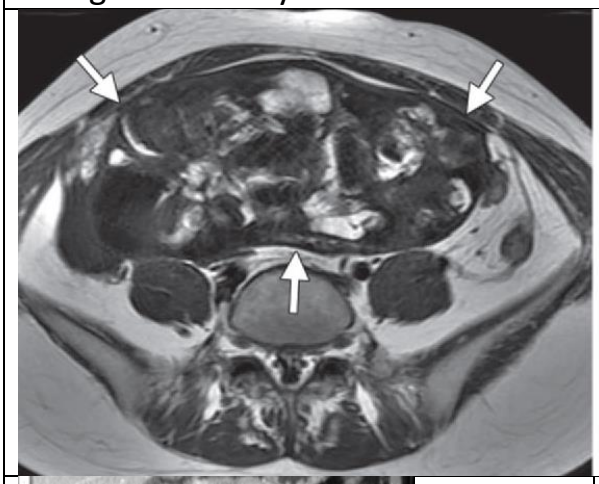
- 2nd most common malignant ovarian germ cell tumor
- 35.6%– 36.2% of malignant ovarian germ cell tumor

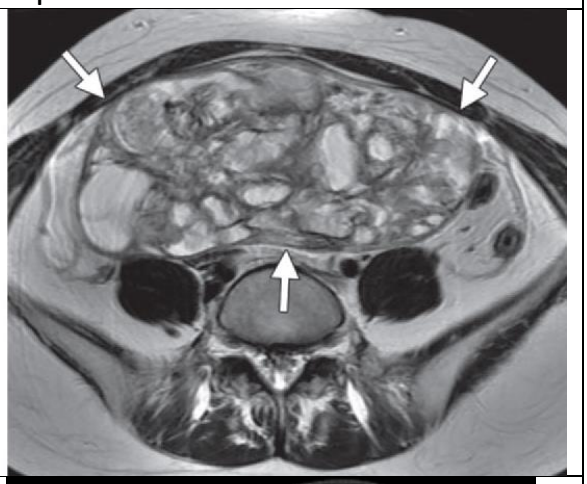
- Age: Women < 20 years old

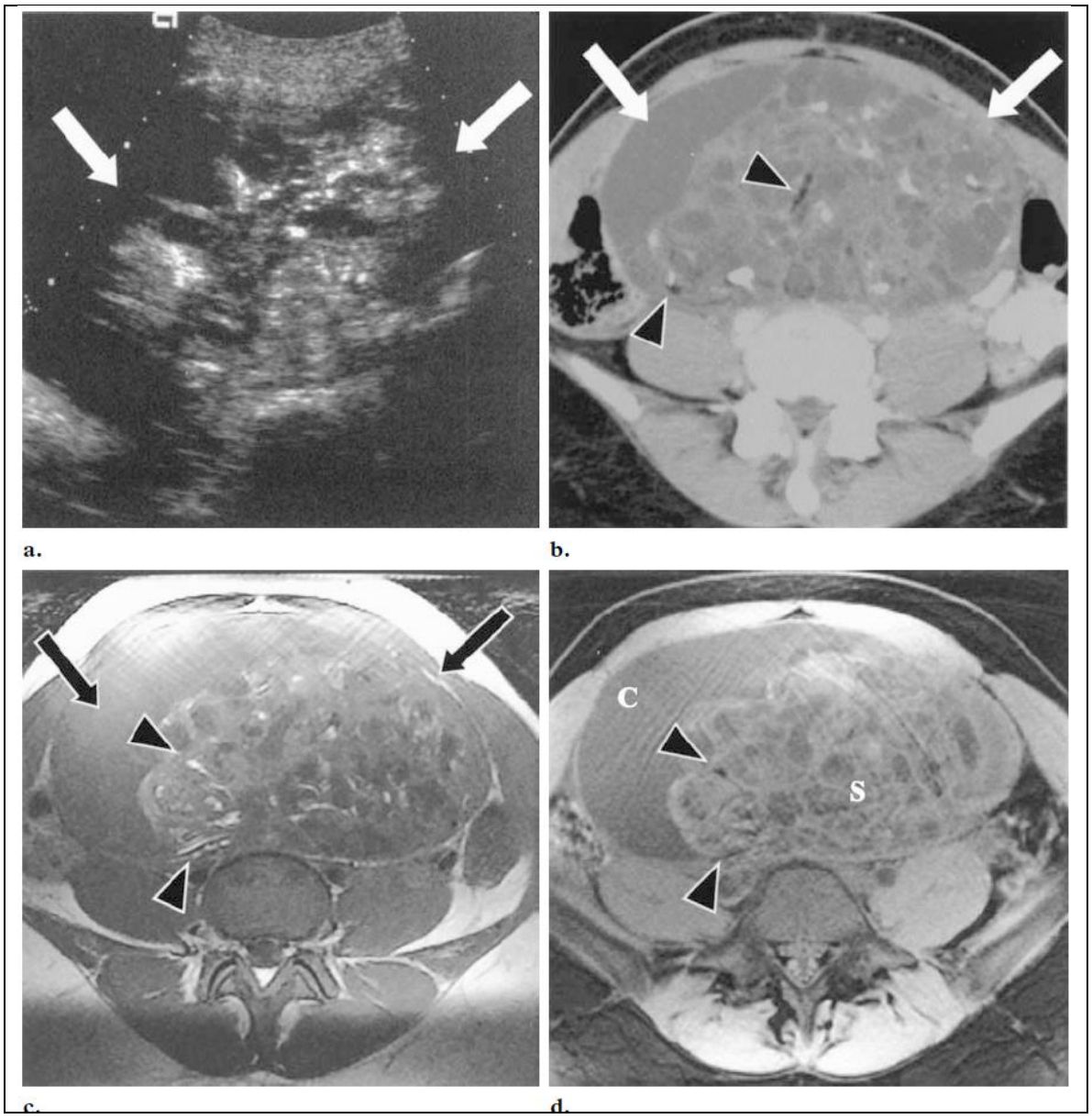
- Immature teratomas consist of tissues derived from the three germ cell layers: ectoderm, mesoderm, and endoderm.

Imaging findings:

- Predominantly solid mass with fatty elements.
- Calcifications: coarse small, irregular, and scattered
- Numerous cysts of variable sizes predominantly have attenuation and signal intensity similar to those of simple fluid.



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4) Malignant Transformation Of Mature Cystic Teratomas

- Rare
- 0.17%–2% among those with a mature cystic teratoma
- 2.9% of malignant ovarian germ cell tumor

- Age: >45 years

Histopathology of associated cancer:

- ***Rokitansky protuberance is a common site for malignant change***
- Most common:
  - **Squamous cell carcinoma: > 80%**
- Other malignant tumors:
  - Carcinoid - Thyroid - Basal cell carcinoma - Intestinal adenocarcinoma
  - Melanoma – Leiomyosarcoma – Angiosarcoma - Chondrosarcoma

Imaging findings of Malignant transformation:

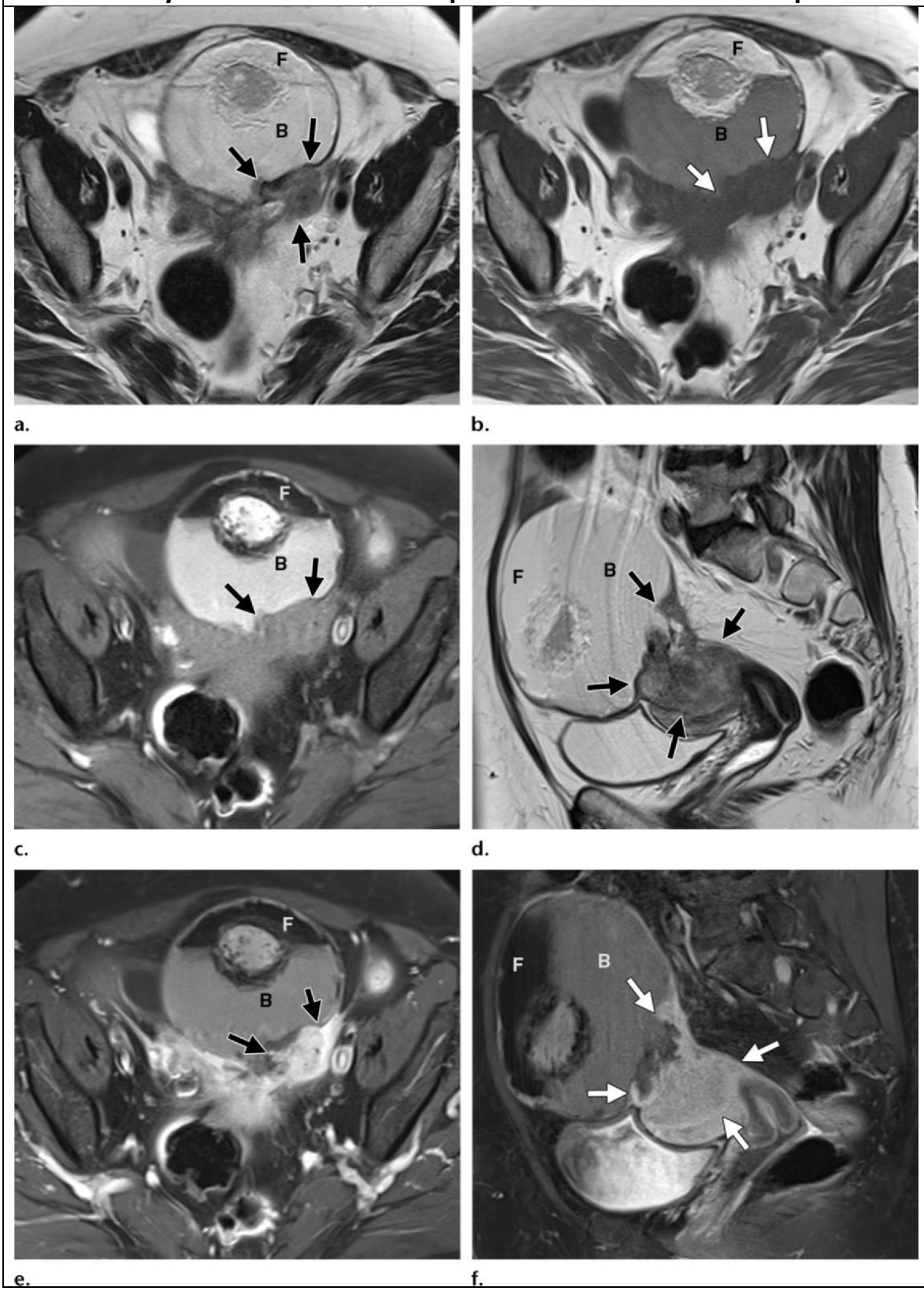
- Heterogeneously irregular solid component with transmural extension and invasion of adjacent organs.
- The presence of an obtuse angle between the soft tissue and inner wall of the cyst
- Pseudomyxoma peritonei is a clinical syndrome that is characterized by mucinous ascites and implants that diffusely involve the peritoneal surfaces

Malignant Transformation Of Mature Cystic Teratoma VS Ovarian Collision Tumor

❖ **Ovarian Collision Tumor:**

- Two adjacent but histologically distinct tumors
- No histologic admixture at the interface.
- Normal ovarian tissue may usually be identified intervening between both tumors
- Most commonly composed of teratoma and cystadenoma or cystadenocarcinoma.

❖ **Mature cystic teratoma with a squamous cell carcinoma component**



5) Yolk Sac Tumor

- 3rd most common ovarian malignant germ cell tumor
- 1% of ovarian malignancies
- 14.5%–16.4% of ovarian malignant germ cell tumor

- Age: common in women in the second and third decades of life

Imaging findings:

- Unilateral enhancing mixed solid and cystic mass
- Hemorrhagic portion.
- Bright dot sign = enhancing foci in the wall or solid components; attributed to dilated vessels, considering the highly vascular nature of these tumors
- Capsular tear

6) Choriocarcinoma

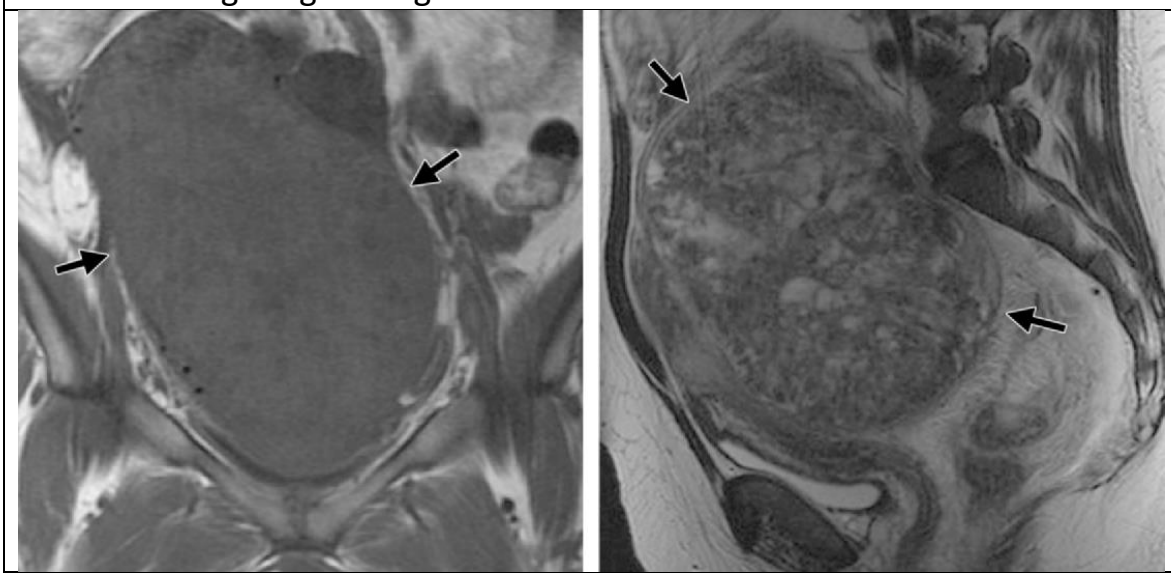
- among the rarest of ovarian malignant germ cell tumor
- 2.1%–3.4% of ovarian malignant germ cell tumor

Adnexal mass + Elevated b-hCG level + reproductive age :

- may cause clinical confusion and an erroneous diagnosis of ectopic pregnancy, a more common condition than ovarian choriocarcinoma

Imaging findings:

- Adenexal enhancing highly vascular solid mass.
- Abnormal large signal voids that represent vascular structures
- Small cystic cavities are seen in solid components
- Hemorrhagic high T1 signal foci



7) Embryonal Carcinoma

- Rare and highly malignant tumor
- 3% of malignant germ cell tumor.
- Isosexual precocity or menstrual irregularity related to b-hCG secretion occurs in up to 60% of cases
- Age: Children and adolescents
- Imaging findings: Predominantly solid, with cystic spaces that contain mucoid material

B- Ovarian Sex Cord–Stromal Tumors

- Derived from the coelomic epithelium (sex cords) and ovarian stroma or mesenchyma of the embryonic gonads.
- Composed of various combinations of granulosa cells, theca cells, Leydig cells, Sertoli cells, and fibroblasts of stromal origin

- 10%–20% of pediatric ovarian tumors
- 5%–10% of ovarian neoplasms in all age groups

1) Granulosa Cell Tumor Group

- Most common malignant ovarian sex Cord–Stromal Tumors
- 70% of all ovarian Sex Cord–Stromal Tumors in patients younger than 20 years.
- Most common estrogen-producing ovarian tumor.

Subdivided into:

- ***Adult type: Perimenpousal***
- ***Juvenile type: first 2 decades of life***

Hyperestrogenemia:

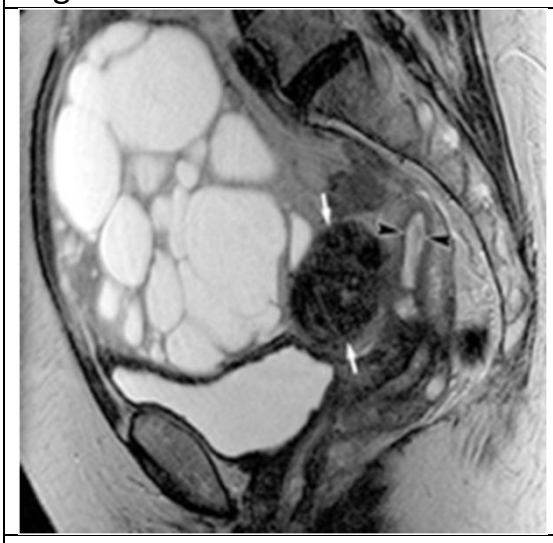
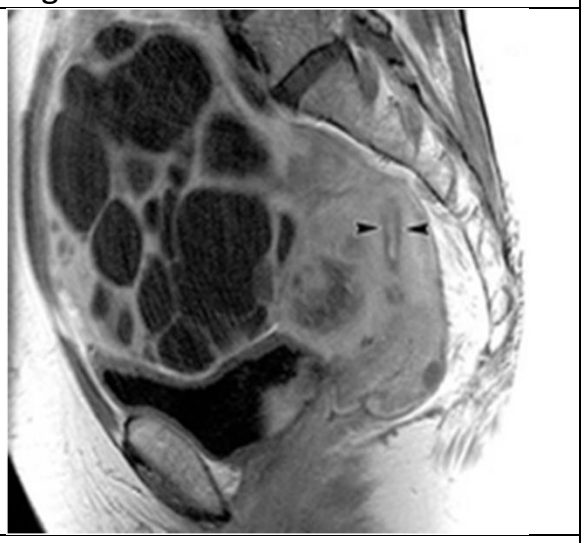
- May produce endometrial hyperplasia, polyps, or carcinoma.
- Present with isosexual precocious puberty related to estrogen secretion

Associations:

- Found in patients with Ollier disease and Maffucci syndrome
- Endometrial carcinoma is associated with these neoplasms in 3%–25%

Imaging findings:

- ***Sponge like appearance:***
  - = Multilocular cystic lesion + Enhancing thick septations
- Endometrial Hyperplasia

Sagittal T2	Sagittal T1+C
	

2) Thecoma-Fibroma Group

- < 2% of all pediatric ovarian tumors
- This tumor group is characterized by fibrous components and includes:
  - Thecoma, fibroma, cellular fibroma, fibrosarcoma, stromal tumor with minor sex cord elements, sclerosing stromal tumor, signet-ring stromal tumor, and fibrothecoma
- Most cases are benign, and surgical resection is curative
- 50% of these tumors are estrogenic.

- **Age: Adult women > 30 years**

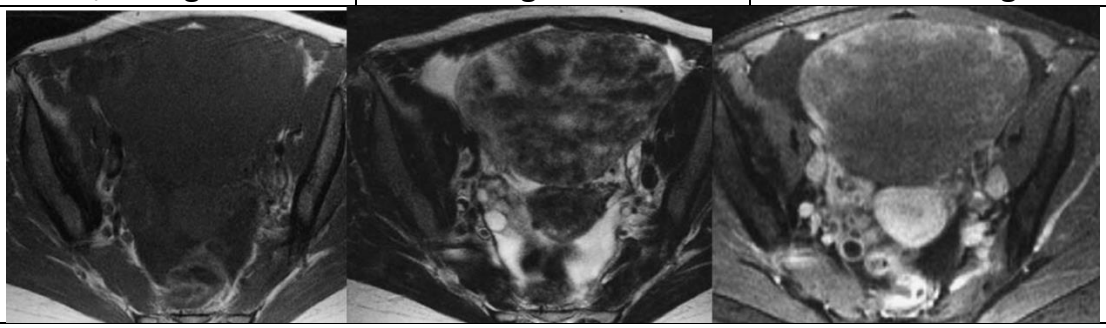
Imaging findings:

- Well defined homogeneous solid mass
- CT: Calcifications
- T1: Low signal
- T2: Low signal + scattered hyperintense areas in the mass represent edema or cystic degeneration
- +C: delayed or variable contrast enhancement, depending on the amount of fibrous content

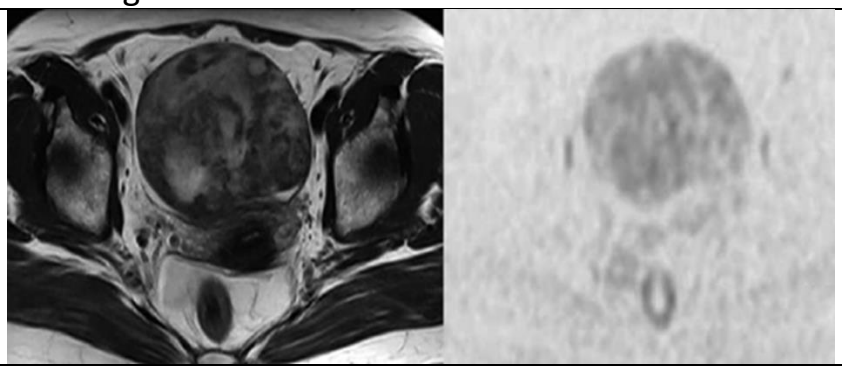
Benign Meigs Syndrome

- Ovarian Fibroma + Ascites + Pleural Effusion

T1: Low/iso signal	T2: Low signal	+C: Mild heterog enh



Mild /Moderate Signal on DWI



3) Sertoli-Leydig Cell Tumor

- Rare stromal tumor
- < 0.5% of all malignant ovarian neoplasms in children

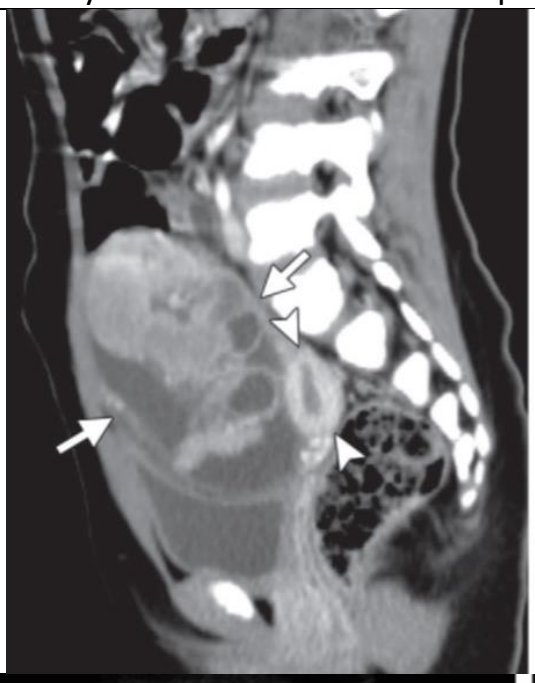
- Age: Women < 30 years.

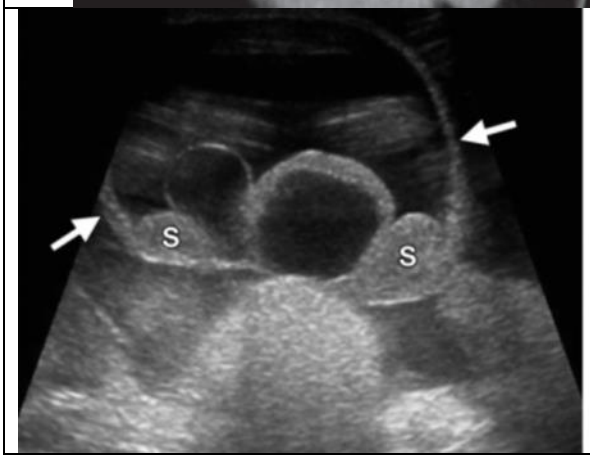
Histologically, the tumor is classified into:

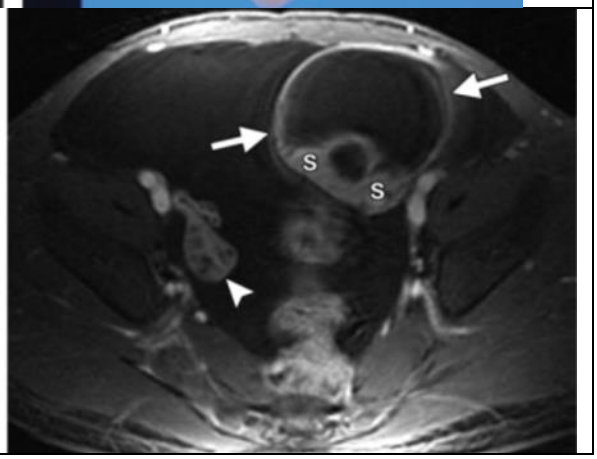
- Well-differentiated, intermediately differentiated, poorly differentiated,

Imaging findings:

- Predominantly solid mass with peripheral or intratumoral cysts
- or a cystic mass with solid mural portions







C- Ovarian Epithelial Tumors

- Epithelial tumors are the most common histopathologic type of malignant ovarian tumor
- 60% of all ovarian neoplasms
- 85% of malignant ovarian neoplasms
- 60% of adult ovarian tumors
- 15%–20% of pediatric ovarian tumors

- **Tumors are further classified on the basis of their histologic and clinical behavior as:**
  - **Benign (60%)**
  - **Malignant (35%)**
  - **Borderline (low-malignant- potential) (5%)**

Histological Subtypes:

- Ovarian serous tumours
  - Ovarian serous cystadenoma: ~60% of serous tumours
  - Ovarian borderline serous cystadenoma: ~15% of serous tumours
  - ***Ovarian serous cystadenocarcinoma: ~25% of serous tumours; commonest malignant ovarian tumour***
- Ovarian mucinous tumours: ~20% of all ovarian tumours
  - Ovarian mucinous cystadenoma: ~80% of mucinous tumours
  - Ovarian bordeline mucinous cystadenoma: 10-15%
  - Ovarian mucinous cystadenocarcinoma: 5-10%
- Ovarian endometrioid tumour: 8-15% of all ovarian tumours
- Clear cell ovarian carcinoma: ~5% of ovarian cancer
- Brenner tumour: ~2.5% of ovarian epithelial neoplasms
- Squamous cell carcinoma of the ovary
- Ovarian cystadenofibroma/ ovarian adenofibroma: can be serous, mucinous, endometrioid, clear cell or mixed
- Ovarian cystadenocarcinofibroma: extremely rare
- Ovarian fibrosarcoma
- Undifferentiated carcinoma of the ovary: ~4% of all ovarian tumours

1) Serous & Mucinous Ovarian Tumors

Features that Help Differentiate Serous from Mucinous Tumors

Feature	Tumor Type: Serous	Tumor Type: Mucinous
Clinical findings		
Benign ovarian tumors	25%	20%
Malignant ovarian tumors	50%	10%
Proportion of malignant cases	60% benign, 15% low malignant potential, 25% malignant	80% benign, 10%–15% low malignant potential, 5%–10% malignant
Imaging findings		
Size	Smaller than mucinous tumors	Often large; may be enormous
Wall, locule	Thin-walled cyst, usually unilocular	Multilocular, small cystic component, honeycomb-like locules
Opacity or signal intensity of locule	Stable	Variable
Papillary projections	Often seen	Rare
Calcification	Psammomatous, common	Linear, rare
Bilaterality	Frequent	Rare
Carcinomatosis	More common	Pseudomyxoma peritonei

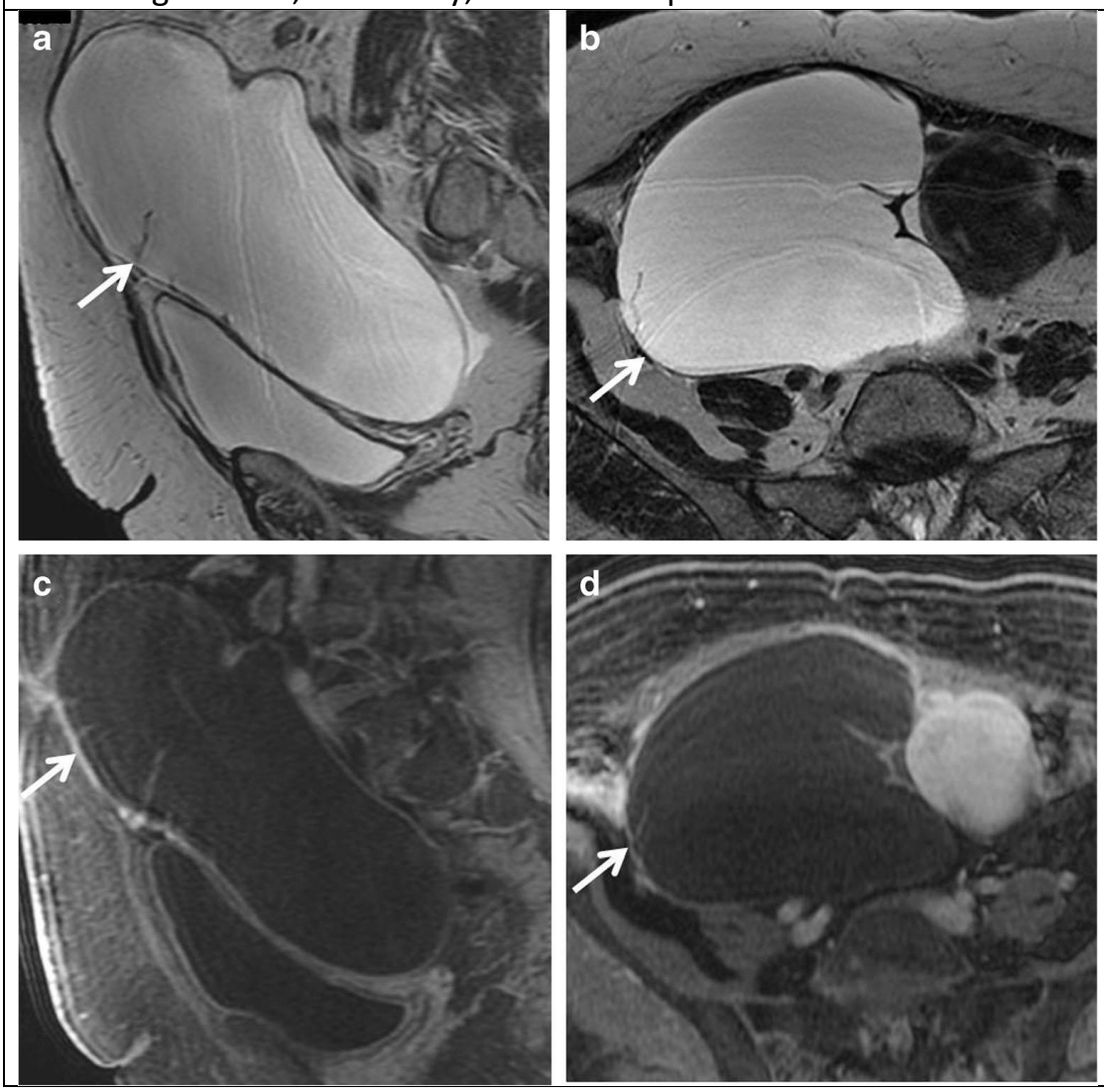
Features that Suggest Either Benign or Malignant Epithelial Neoplasms

Variable	Tumor Type: Benign	Tumor Type: Malignant
Component	Entirely cystic	Large soft-tissue mass with necrosis
Wall thickness	Thin (less than 3 mm)	Thick
Internal structure	Lacking	Papillary projection
Ascites	None	Peritoneal, anterior to uterus
Other	. . .	Peritoneal implants, pelvic wall invasion, adenopathy

- ***Bilateral Serous cystadenocarcinoma in 50% of cases***
- ***Bilateral Mucinous cystadenocarcinoma in 20% of cases***

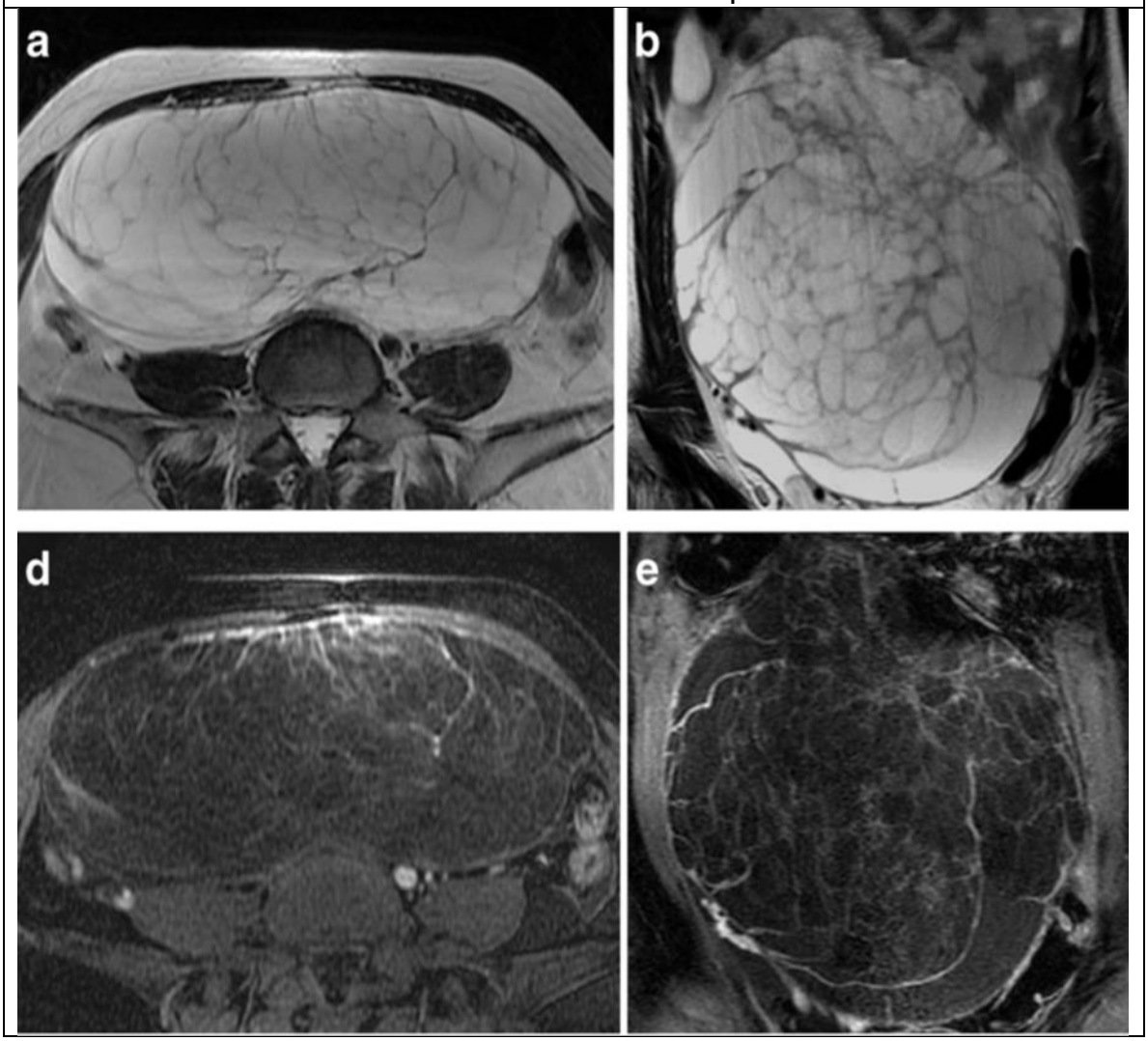
❖Ovarian Serous Cystadenoma

- Unilocular cystic mass
- CT: Fluid density
- T1: Low signal
- T2: High signal
- +C: The cyst wall shows poor contrast enhancement
- N0 vegetations, nodularity, or solid components



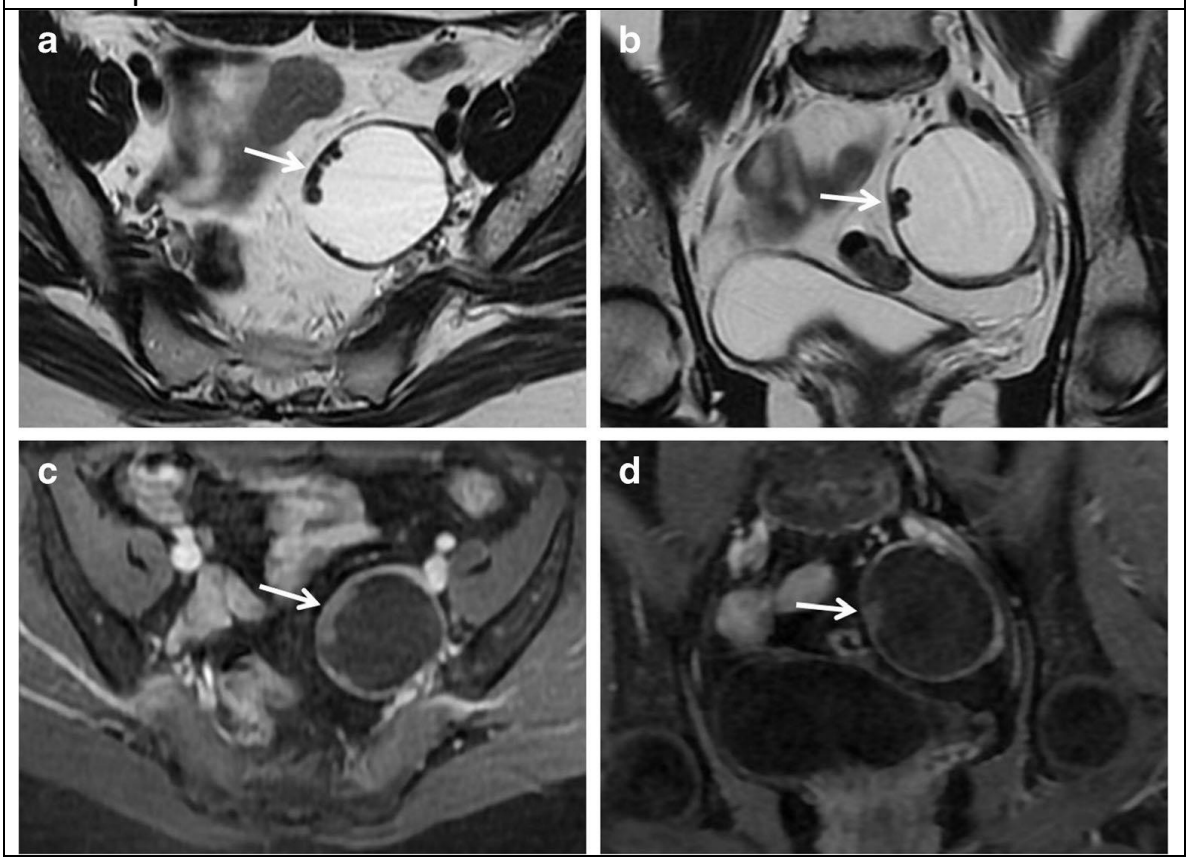
❖Ovarian Mucinous Cystadenoma

- Multilocular cystic mass with several septations
- The locules may contain complex fluid, due to proteinaceous debris or hemorrhage, or both.
- Poor enhancement of the tumour wall and septa



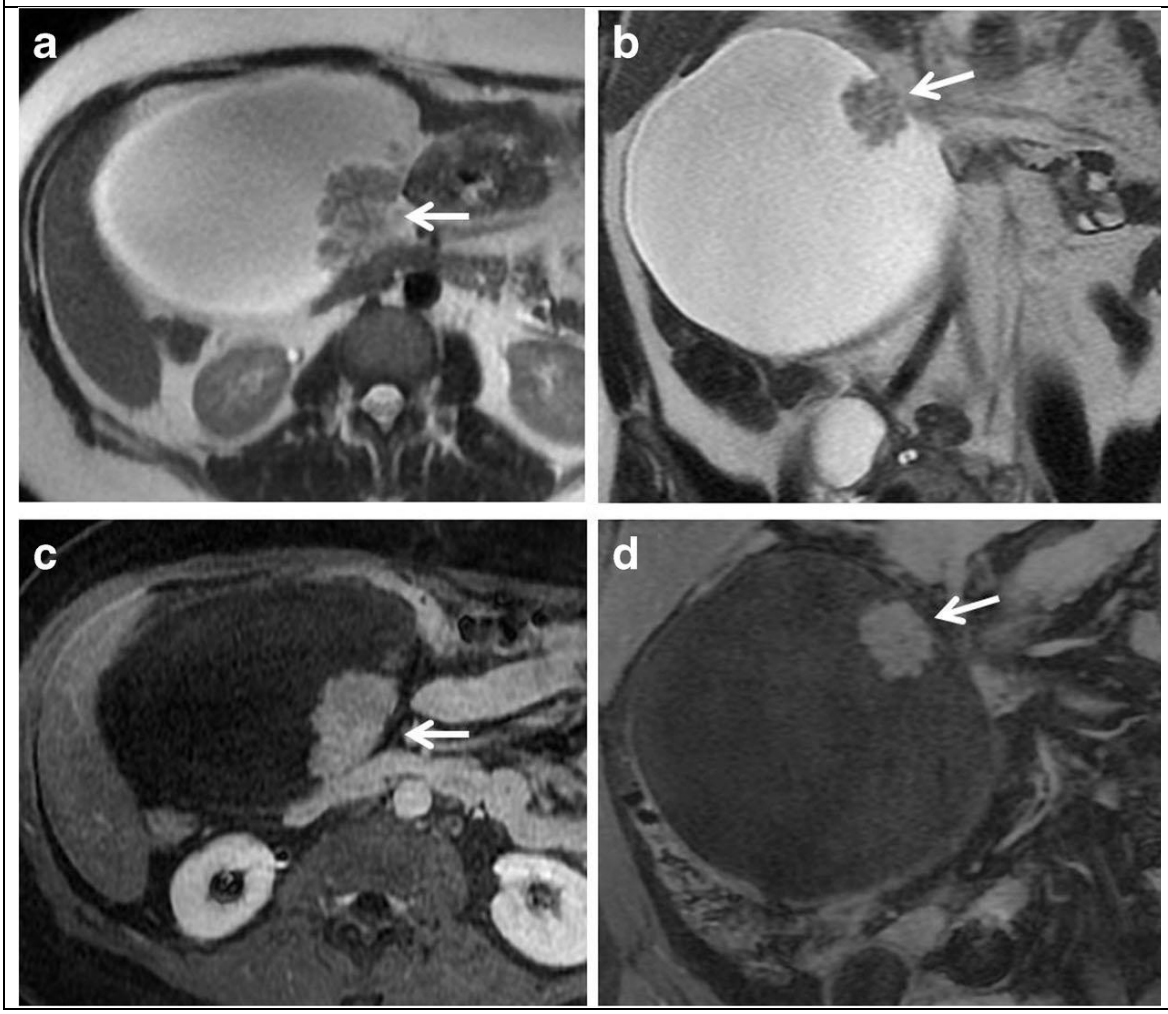
❖Ovarian Cystadenofibroma

- Predominantly cystic mass with small areas of fibrous stroma along the wall
- T2: homogeneous low signal intensity
- +C: Minimum enhancement of the cystic wall and of the fibrous component



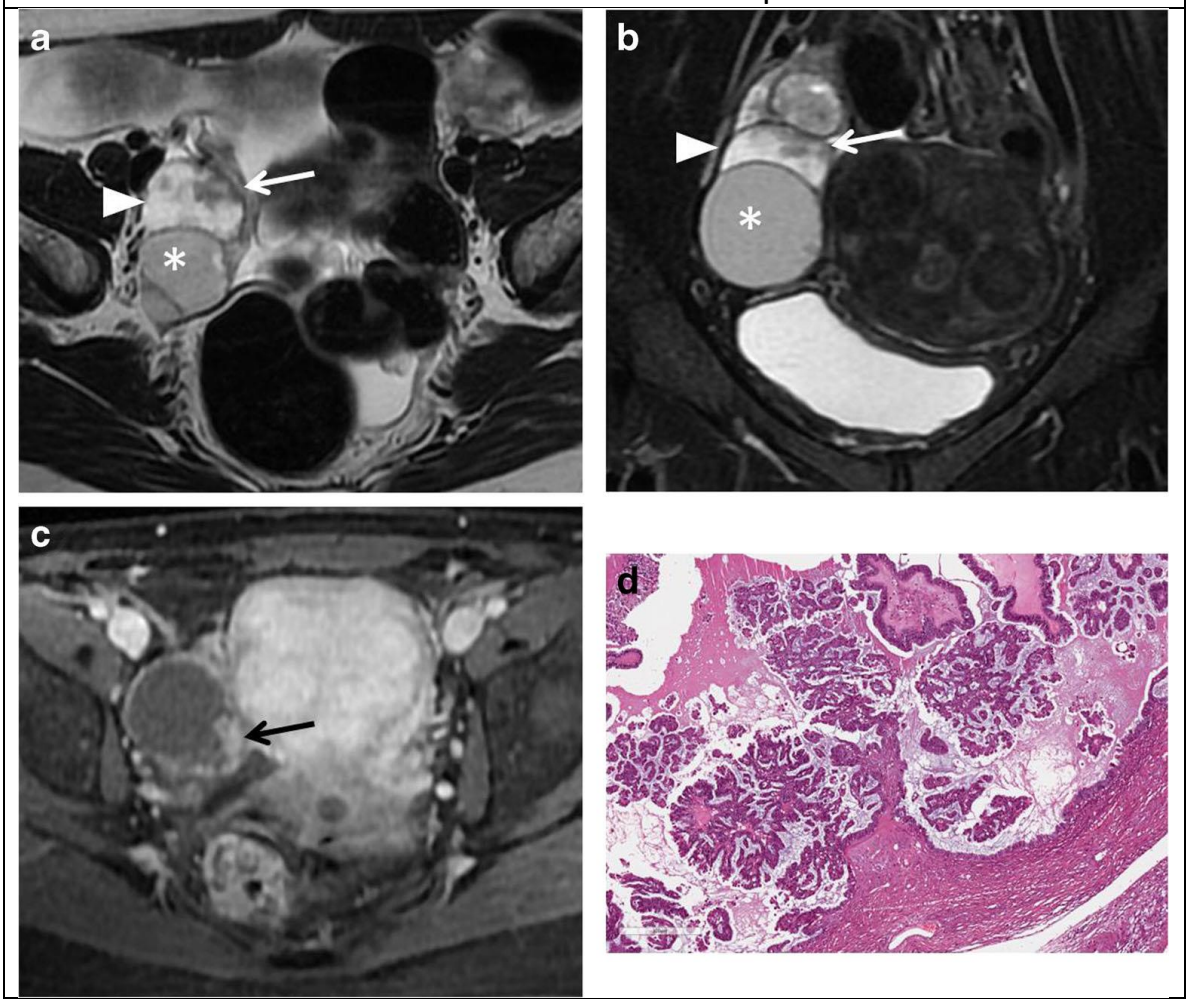
❖Borderline Papillary-Cystic Serous Tumour

- A cystic mass with papillary projections arising from the wall
- Enhancement of the parietal solid component
- No stromal invasion



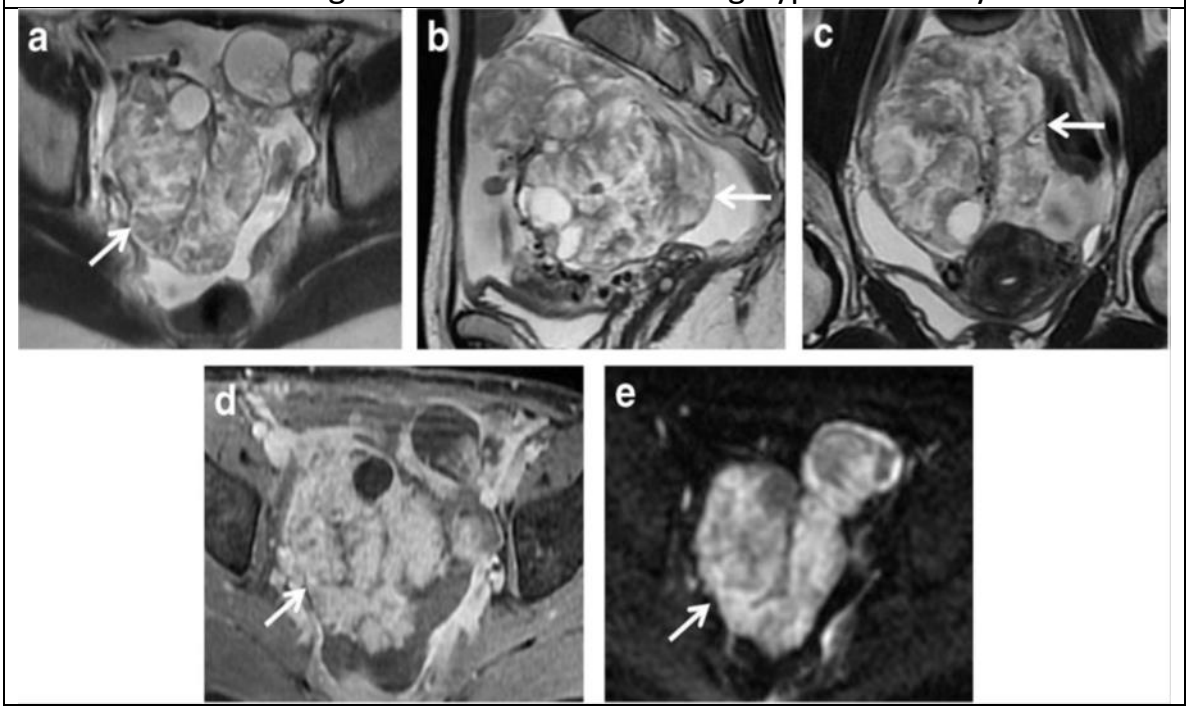
❖Borderline Mucinous Ovarian Tumour

- Multiloculated cystic ovarian tumour and solid parietal component
- Loculi with intermediate to high (white arrowheads) signal
- Enhancement of the wall and of the solid component



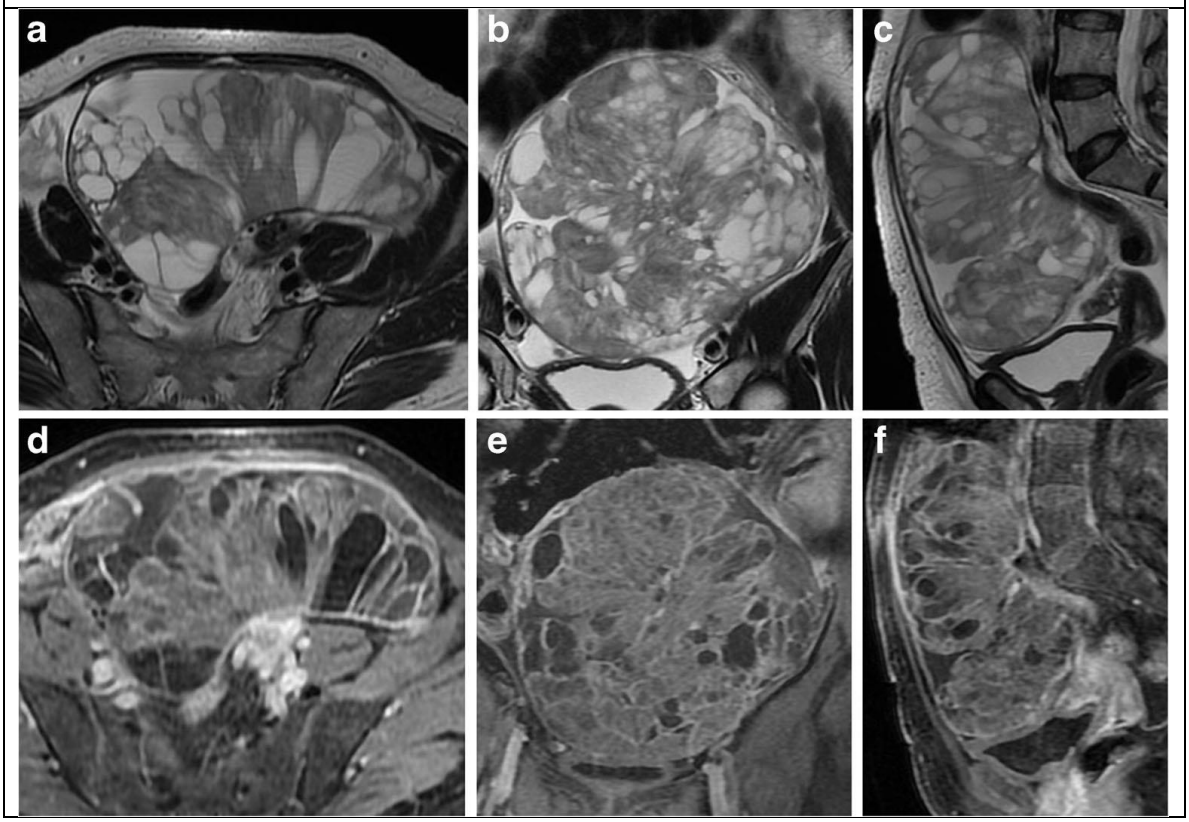
❖Serous Papillary Cystadenocarcinoma

- Most common type of ovarian malignancy (approximately 40% of cases)
- Cystic and solid mass
- +C: Enhancing exophytic papillary projections
- DWI: Increased signal of the lesion indicating hypercellularity



❖Mucinous Cystadenocarcinoma

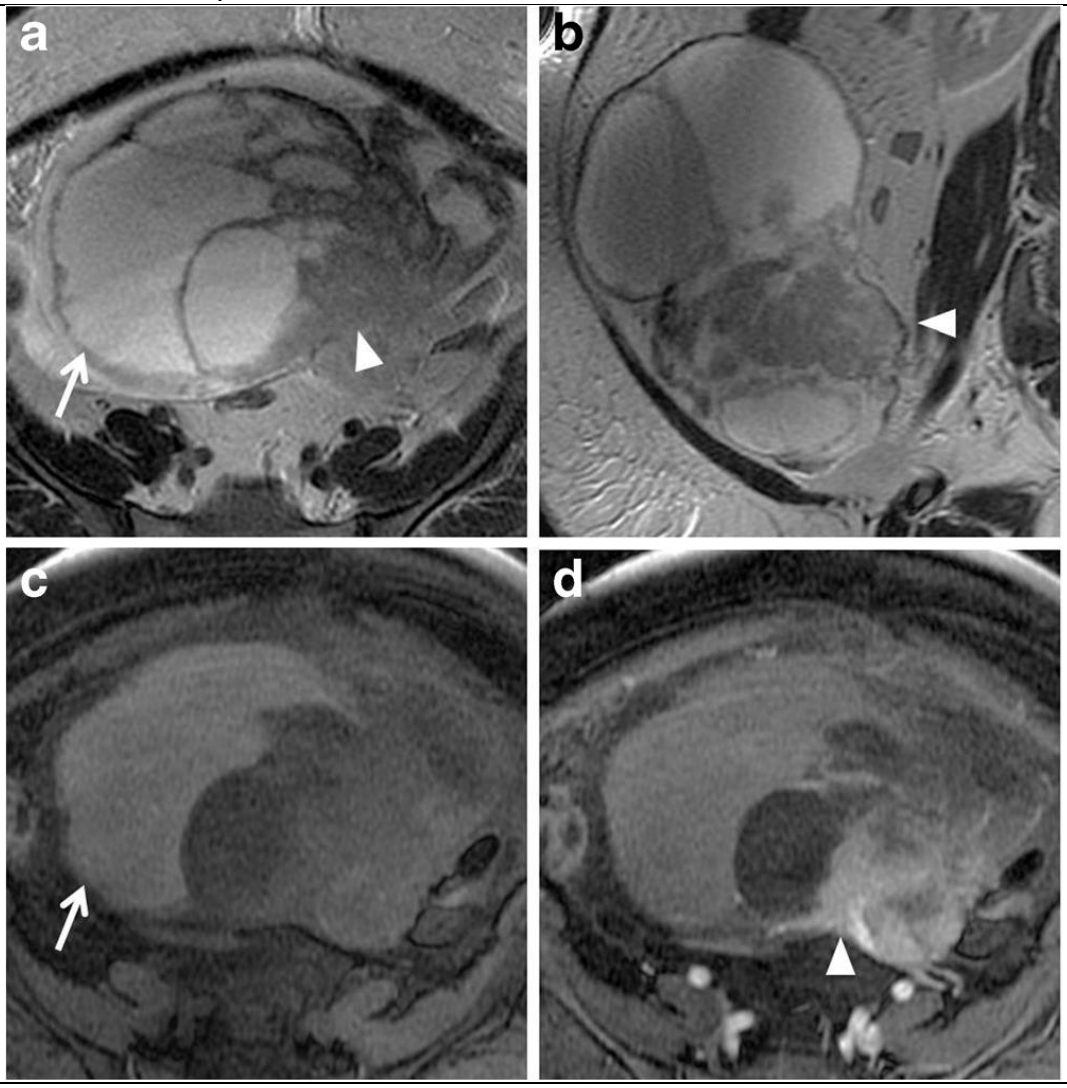
- Large mass with mixed solid and multilocular cystic appearance
- Variable signal intensity within the locules (Stained glass appearance).
- +C: marked enhancement of the solid component, wall and septa of the tumour

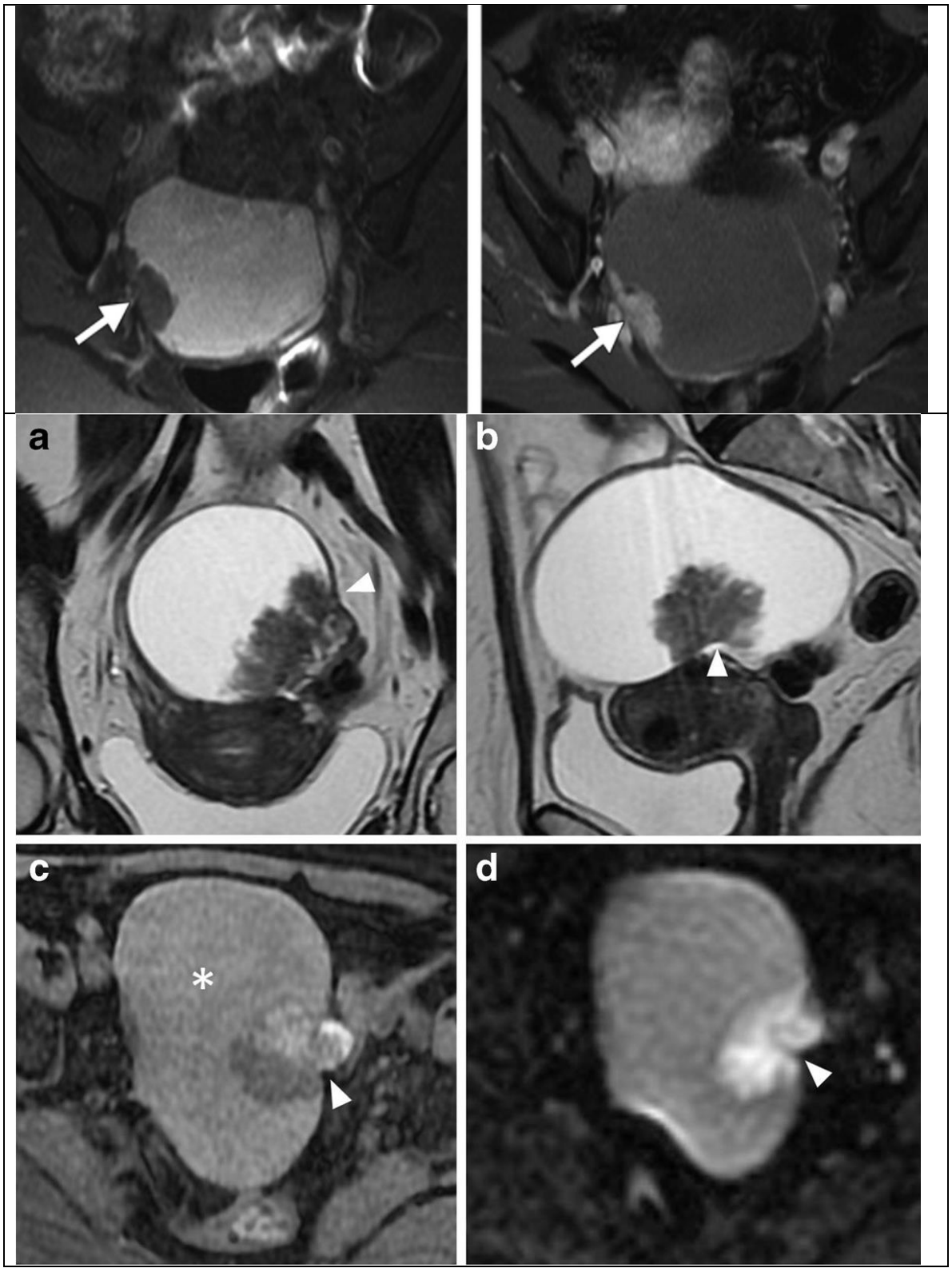


2) Endometrioid Adenocarcinoma

- They are almost always malignant.
- 10%–15% of all ovarian carcinomas.
- Endometrioid carcinoma and clear cell tumours are commonly associated with endometriosis
- Endometrioid carcinoma is the most common malignant neoplasm arising within an endometrioma.
- Synchronous endometrial carcinoma or endometrial hyperplasia : may be present in upto a 1/3rd of cases
- Bilateral Endometrioid carcinoma in 25% of cases.

- Complex masses with solid and cystic components.
- The cystic component shows haemorrhagic hyperintense T1 signal
- The solid component shows marked enhancement

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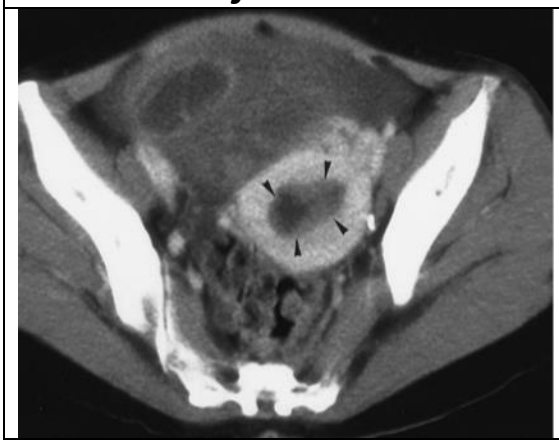
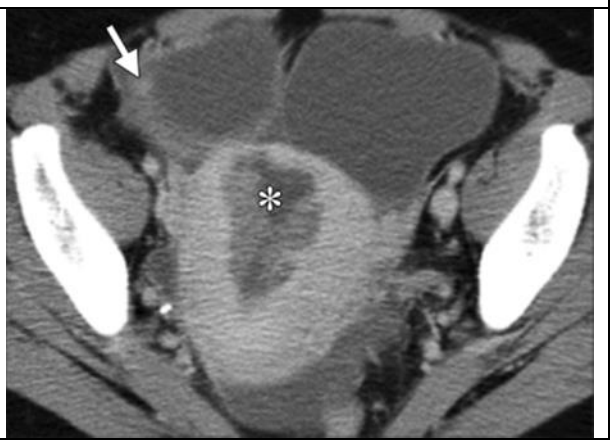
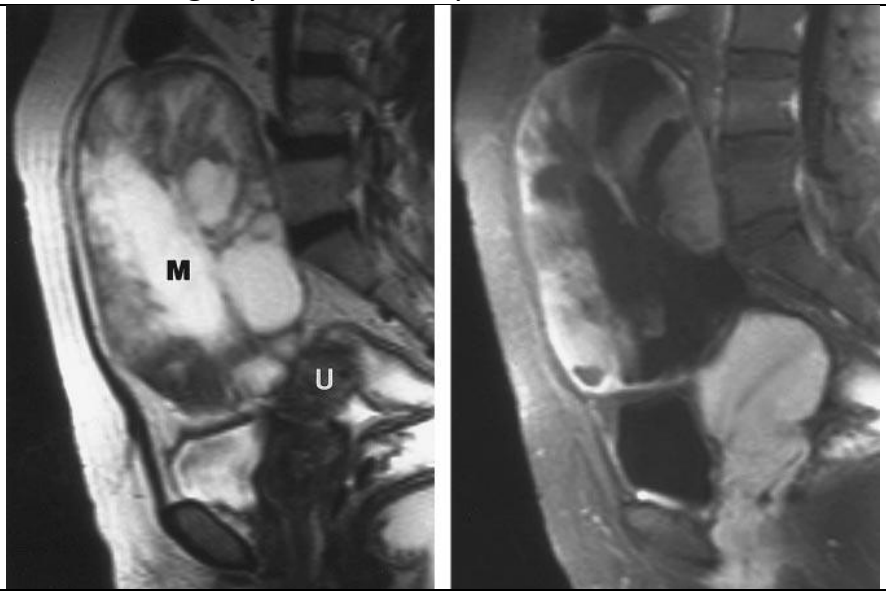
Endometrioid carcinoma of the ovary and endometrial carcinoma of the uterus	*Synchronous endometrial carcinoma and bilateral endometrioid ovarian cancer*
	

3) Clear Cell Carcinoma

- 5% of ovarian carcinomas
- are always malignant
- Endometrioid carcinoma and clear cell tumours are commonly associated with endometriosis

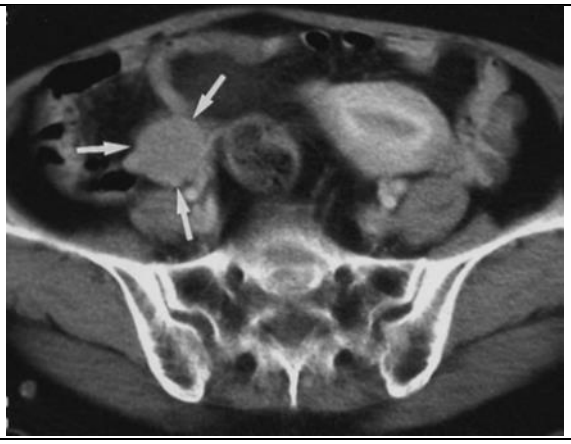
- A large endometrioma with solid components suggests malignancy and must be removed
- A unilocular or large cyst with solid protrusions



4) Brenner Tumor

- Brenner tumors are composed of transitional cells with dense stroma.
- 2%–3% of ovarian tumors and are rarely malignant.
- Brenner tumors are usually small (<2 cm)
- Discovered incidentally, but affected patients may present with a palpable mass or pain.
- Brenner tumors are associated with other ovarian tumors in 30% of cases

- Small, ovoid solid mass with homogeneous enhancement



FIGO System For Ovarian Cancer Staging

Stage I Tumour confined to ovaries

I A Tumour limited to 1 ovary, capsule intact, no tumour on surface, negative washings

I B Tumour involves both ovaries otherwise like IA

I C Tumour limited to 1 or both ovaries

- I C1 Surgical spill
- I C2 Capsule rupture before surgery or tumour on ovarian surface
- I C3 Malignant cells in the ascites or peritoneal washings

Stage II Tumour involves 1 or both ovaries with pelvic extension (below the pelvic brim) or primary peritoneal cancer

II A Extension and/or implant on uterus and/or Fallopian tubes

II B Extension to other pelvic intraperitoneal tissues

Stage III Tumour involves one or both ovaries with cytologically or histologically confirmed spread to the peritoneum outside the pelvis and/or metastasis to the retroperitoneal lymph nodes

III A Positive retroperitoneal lymph nodes and /or microscopic metastasis beyond the pelvis

III A1 Positive retroperitoneal lymph nodes only

III A2 Microscopic, extrapelvic (above the brim) peritoneal involvement ± positive retroperitoneal lymph nodes

III B Macroscopic, extrapelvic, peritoneal metastasis ≤2cm ± positive retroperitoneal lymph nodes. Includes extension to capsule of liver/spleen

III C Macroscopic, extrapelvic, peritoneal metastasis >2cm ± positive retroperitoneal lymph nodes. Includes extension to capsule of liver/spleen

Stage IV Distant metastasis excluding peritoneal metastasis

IVA Pleural effusion with positive cytology

IV B Hepatic and/or splenic parenchymal metastasis, metastasis to extraabdominal organs (including inguinal lymph nodes and lymph nodes outside of the abdominal cavity)

A- Local Spread

i) Direct invasion in the pelvis most commonly involves the fallopian tubes, uterus, and contralateral adnexa.

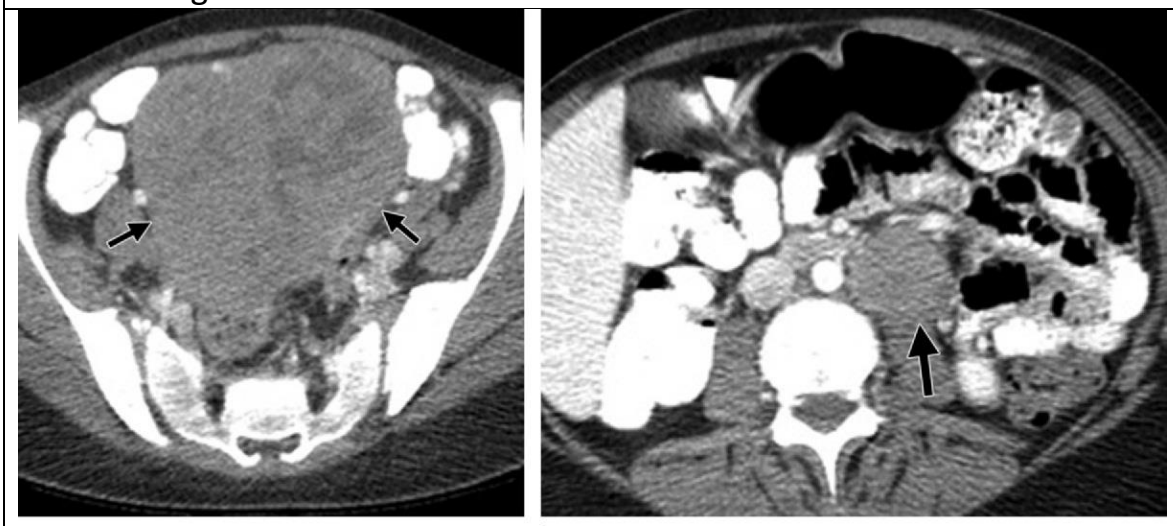
B-Lymphatic Spread

3 routes of lymphatic drainage of the ovary are along:

i) The main route is along the ovarian veins
   ⇨ Paraaortic and paracaval LNs

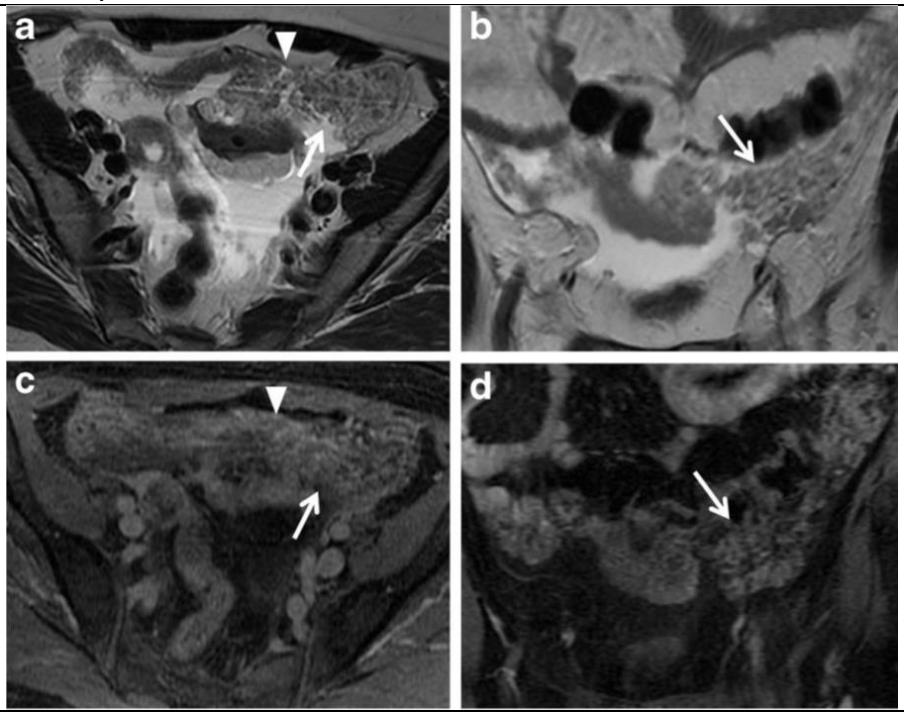
ii) The lymphatics drain along the broad ligament:
   ⇨ internal and external iliac LNs
   ⇨ Junctional nodes at the junction between the internal and external iliac LNs groups.

iii) The third route of drainage is along the round ligament
   ⇨ Inguinal LNs.

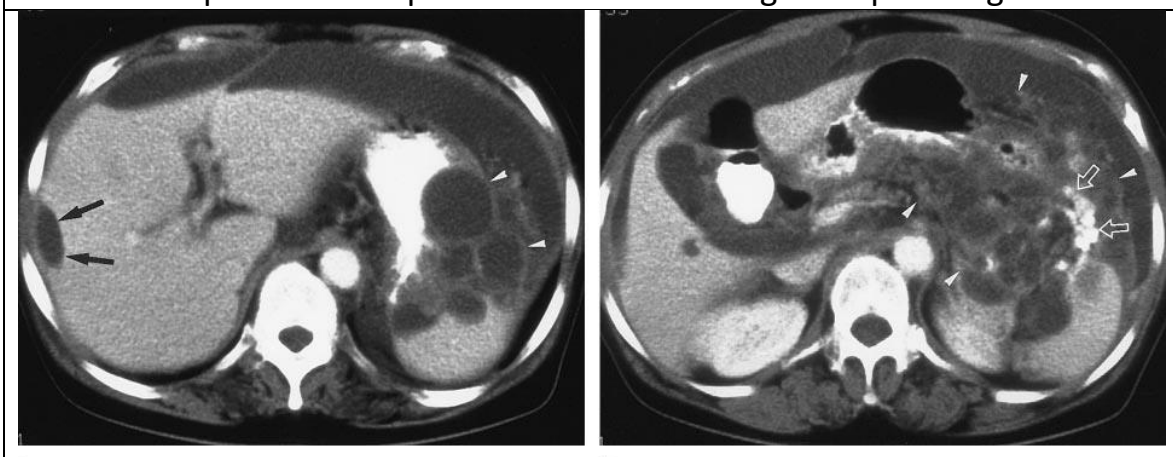


C- Peritoneal Carcinomatosis

- Multiple tumour implants are seen at the left paracolic gutter and omental implants



- Subcapsular hepatic implant with a scalloped margin
- Diffuse multilocular cystic implants are seen along the greater omentum, parietal peritoneum, gastrosplenic ligament, and lesser sac
- Calcified peritoneal implants are noted in the gastrosplenic ligaments



a. b.

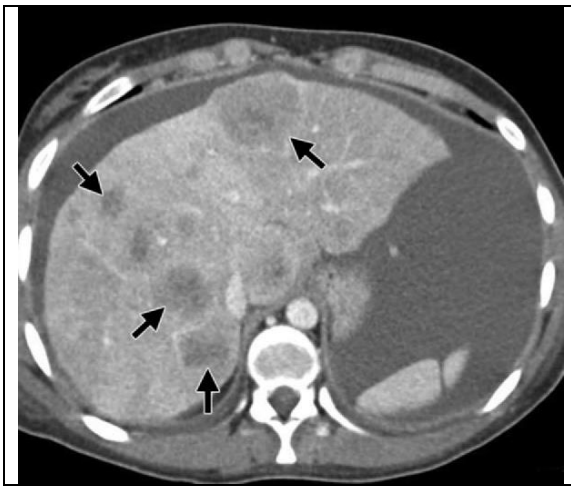
❖Pseudomyxoma Peritonei

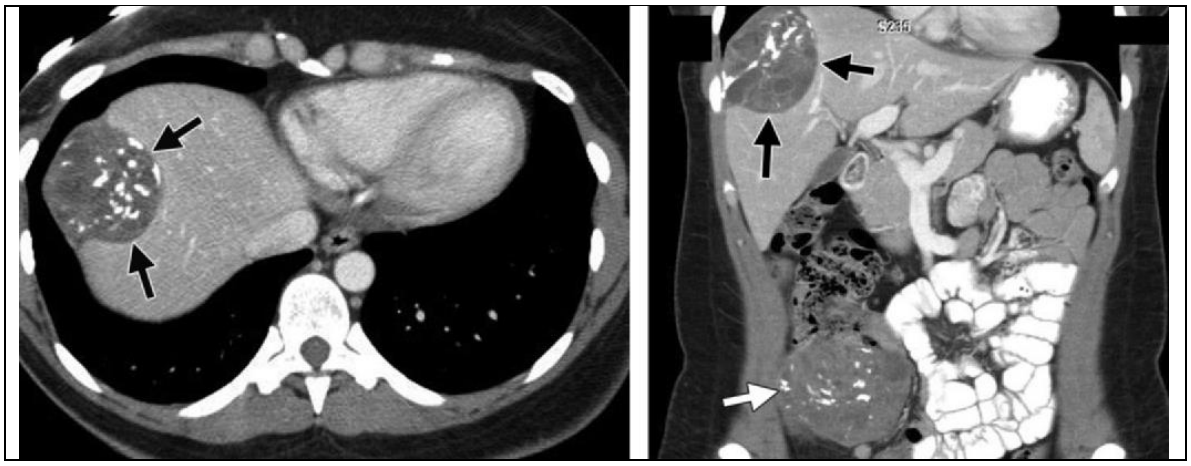
- Represents implants of mucinous appendiceal or ovarian tumor contents on the peritoneal surfaces and is most commonly seen with borderline or well-differentiated carcinoma

- The MR imaging appearance of pseudomyxoma is similar to that of mucin containing peritoneal cyst.
- Loculi with watery mucin:
    - T1: Low signal
    - T2: High signal
- Loculi with thicker mucin:
    - T1: Intermediate – Low signal
    - T2: Low signal

D- Distant Metastases

- Hematogenous metastases are rare at the time of initial presentation.
- They may be seen in the liver - lungs - brain, bones – adrenal glands
- The most common finding of distant metastases is malignant pleural effusion





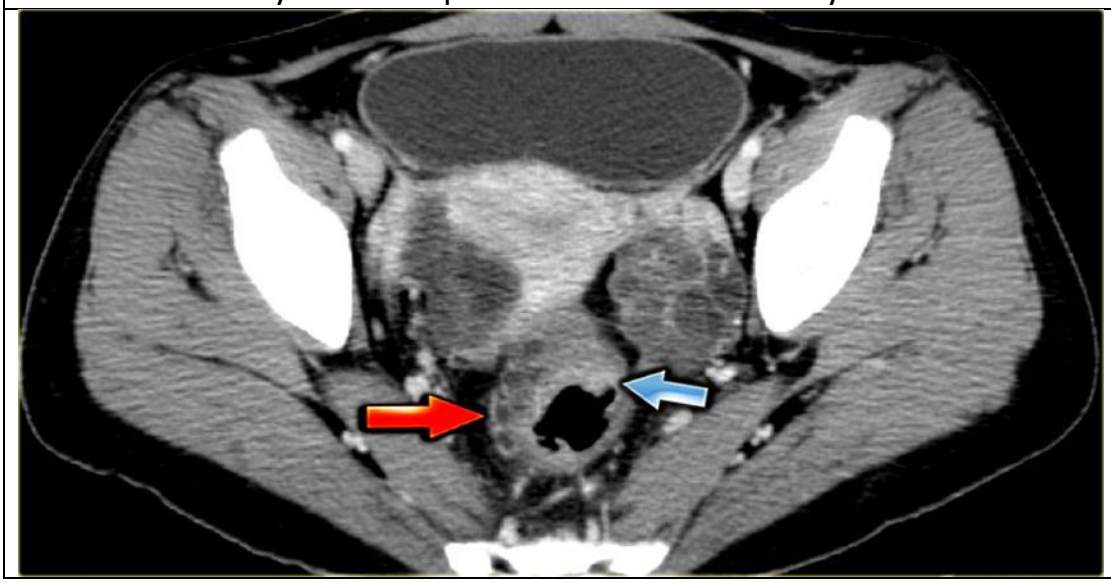
D- Metastatic Ovarian Tumors

Primary tumor sites:

- Colon and stomach are the most common in ovarian metastasis,
- Followed by the breast, lung, and contralateral ovary.

- Krukenberg tumors are metastatic tumors to the ovary that contain mucin-secreting “signet ring” cells and usually originate in the gastrointestinal tract

- Imaging findings in metastatic lesions are nonspecific:
- Predominantly solid components or a mixture of cystic and solid areas

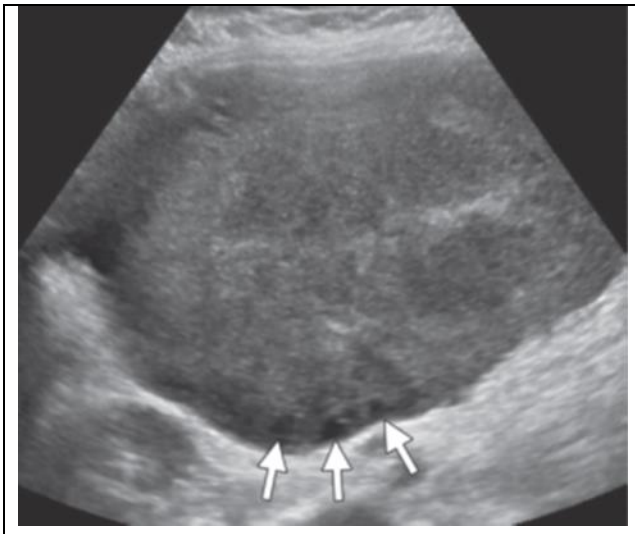


E- Malignant Lymphoma and Leukemia

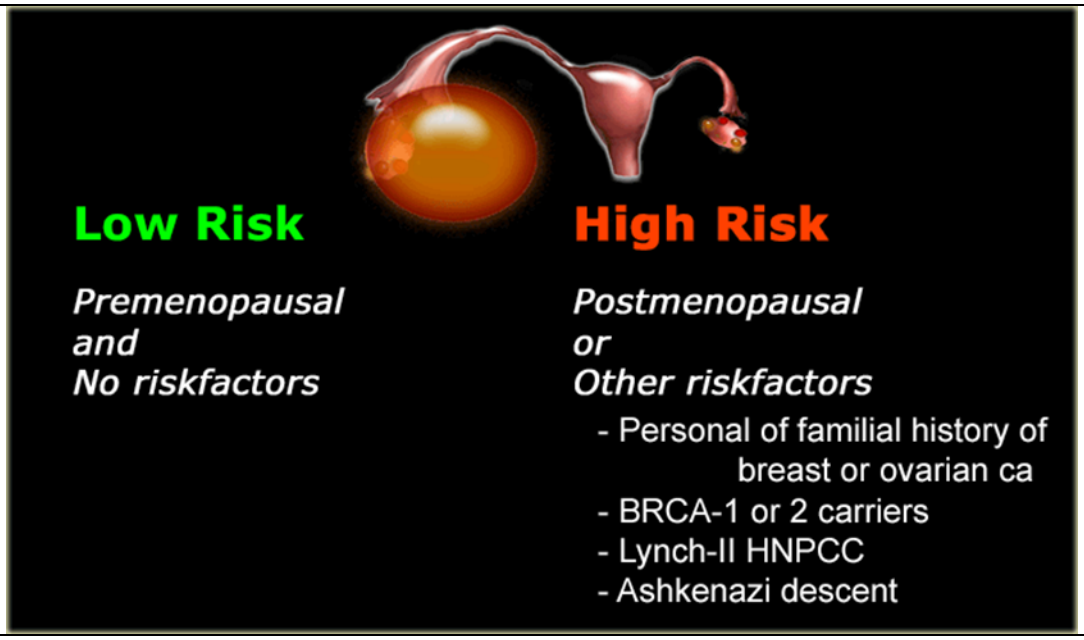
- Although the ovary is the most common site of hematologic malignancy in the female genital tract, lymphoma or leukemic involvement of the ovary occurs rarely.
- < 2% of all pediatric ovarian tumors

Imaging findings:

- Unilateral or bilateral predominantly solid masses
- Homogeneous contrast enhancement
- T2: hypointense
- Small cysts in the periphery of solid portion, which correspond to preserved ovarian follicles



Follow up Guidelines is 2010 consensus statement by the Society of Radiologists in Ultrasound for simple ovarian cysts with no suspicious features on US



In women of reproductive age

≤3 cm

- Normal physiologic finding; at the discretion of the interpreting physician whether or not to describe them in the imaging report
- do not need follow-up

>3 and ≤5 cm

- should be described in the imaging report with a statement that they are almost certainly benign
- do not need follow-up

>5 and ≤7 cm

- should be described in the imaging report with a statement that they are almost certainly benign
- increased risk of ovarian torsion
- yearly follow-up with ultrasound recommended

>7 cm

- may be difficult to assess completely with ultrasound and further imaging with MR or surgical evaluation should be considered

In post-menopausal women

≤1 cm

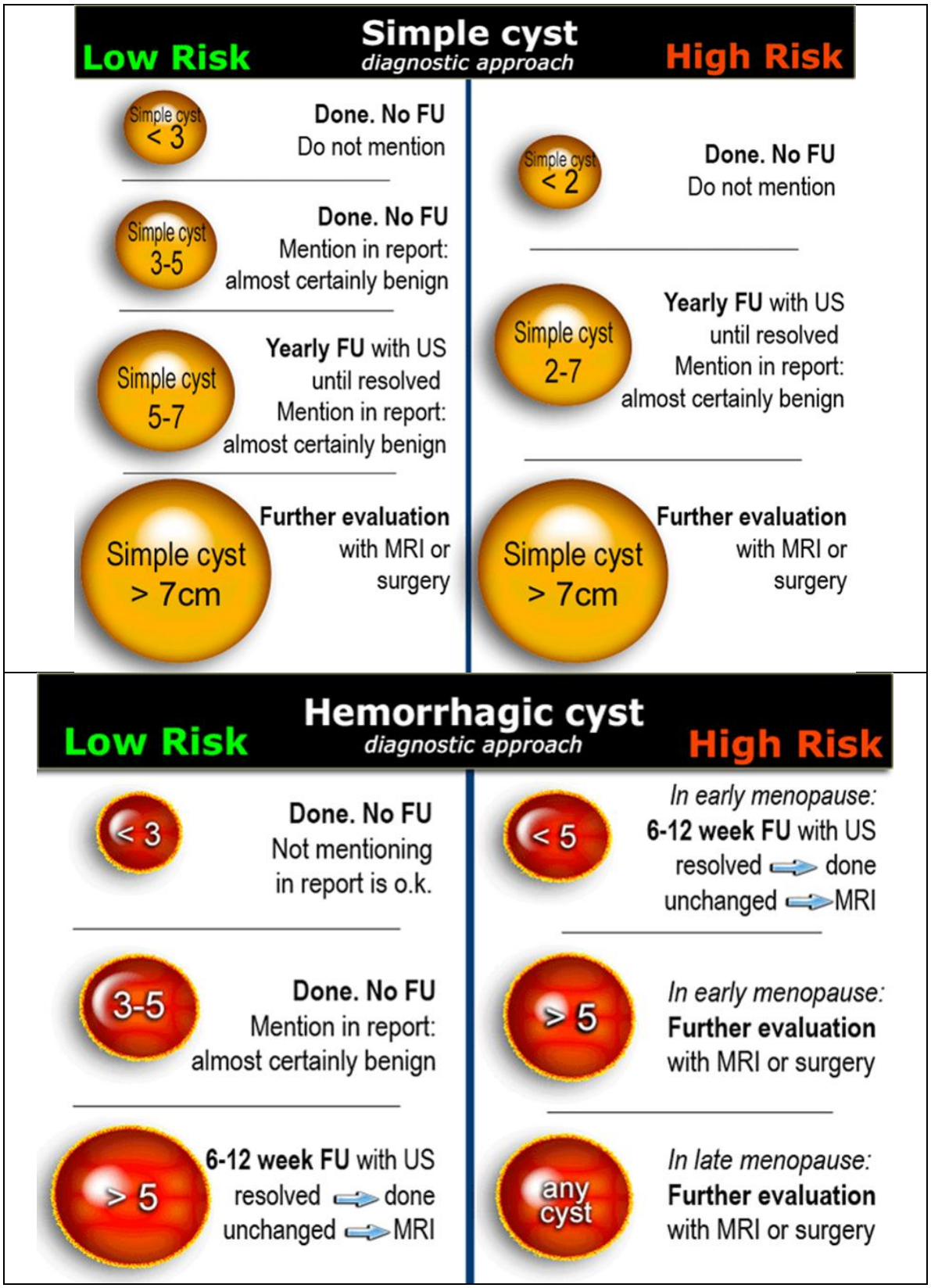
- are clinically inconsequential; at the discretion of the interpreting physician whether or not to describe them in the imaging report
- do not need follow-up

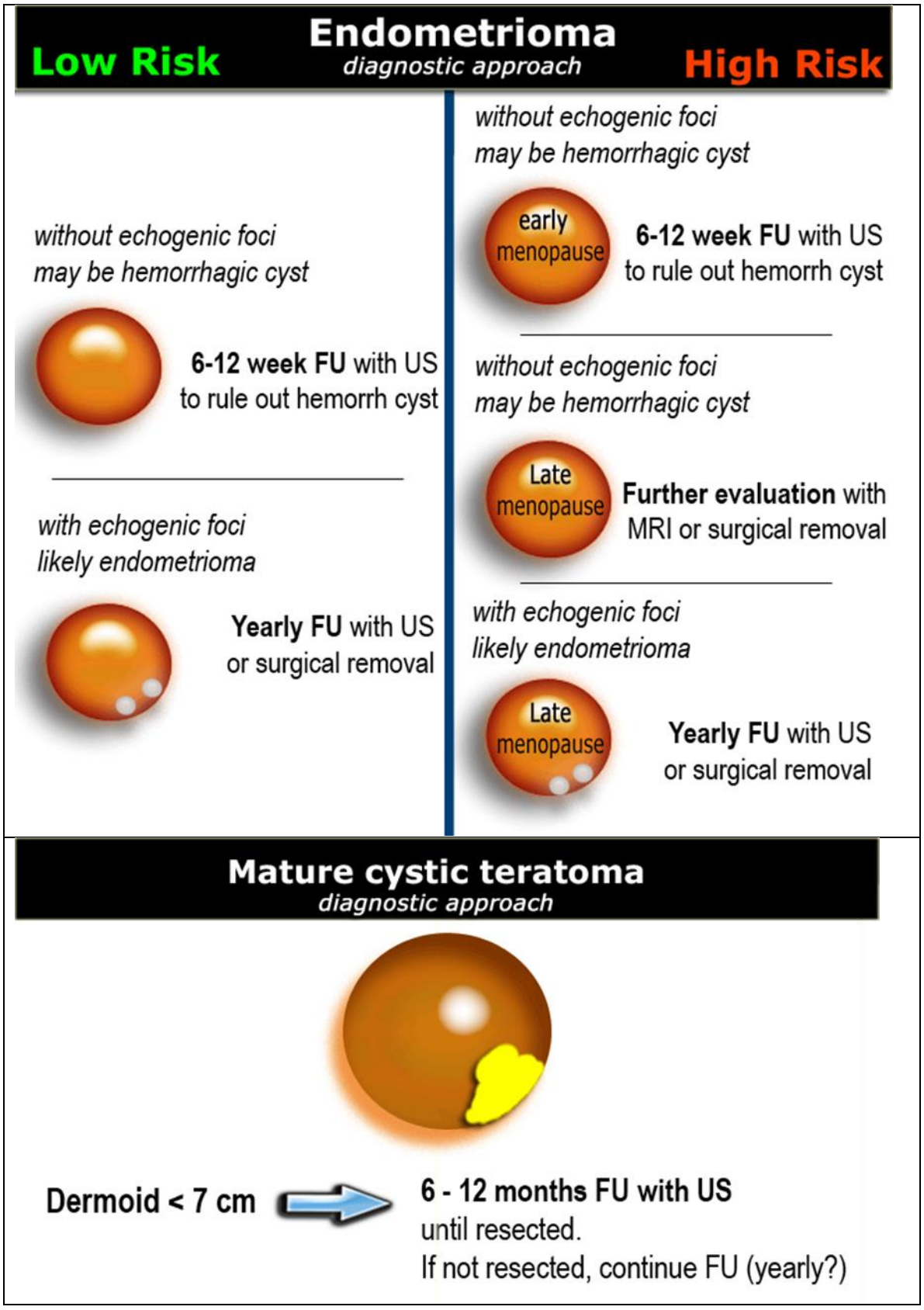
>1 and ≤7 cm

- should be described in the imaging report with a statement that they are almost certainly benign
- yearly follow-up, at least initially, with ultrasound recommended
- some practices may opt to increase the lower size threshold for follow-up from 1 cm to as high as 3 cm
- one may opt to continue follow-up annually or to decrease the frequency of follow-up once stability or decrease in size has been confirmed
- cysts in the larger end of this range should still generally be followed on a regular basis

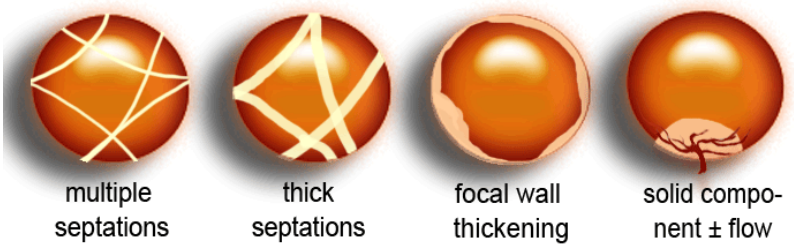
>7 cm

- since these may be difficult to assess completely with ultrasound, further imaging with MRI or surgical evaluation should be considered


Simple cyst
diagnostic approach
Low Risk
High Risk
Simple cyst < 3
Done. No FU
Do not mention
Simple cyst 3-5
Done. No FU
Mention in report:
almost certainly benign
Simple cyst 5-7
Yearly FU with US
until resolved
Mention in report:
almost certainly benign
Simple cyst > 7cm
Further evaluation
with MRI or
surgery
Simple cyst < 2
Done. No FU
Do not mention
Simple cyst 2-7
Yearly FU with US
until resolved
Mention in report:
almost certainly benign
Simple cyst > 7cm
Further evaluation
with MRI or
surgery
Hemorrhagic cyst
diagnostic approach
Low Risk
High Risk
< 3
Done. No FU
Not mentioning
in report is o.k.
3-5
Done. No FU
Mention in report:
almost certainly benign
> 5
6-12 week FU with US
resolved done
unchanged MRI
< 5
In early menopause:
6-12 week FU with US
resolved done
unchanged MRI
> 5
In early menopause:
Further evaluation
with MRI or surgery
any cyst
In late menopause:
Further evaluation
with MRI or surgery


Endometrioma
diagnostic approach
Low Risk
High Risk
without echogenic foci
may be hemorrhagic cyst
6-12 week FU with US
to rule out hemorrh cyst
with echogenic foci
likely endometrioma
Yearly FU with US
or surgical removal
without echogenic foci
may be hemorrhagic cyst
early menopause
6-12 week FU with US
to rule out hemorrh cyst
without echogenic foci
may be hemorrhagic cyst
Late menopause
Further evaluation with
MRI or surgical removal
with echogenic foci
likely endometrioma
Late menopause
Yearly FU with US
or surgical removal
Mature cystic teratoma
diagnostic approach
Dermoid < 7 cm
6 - 12 months FU with US
until resected.
If not resected, continue FU (yearly?)

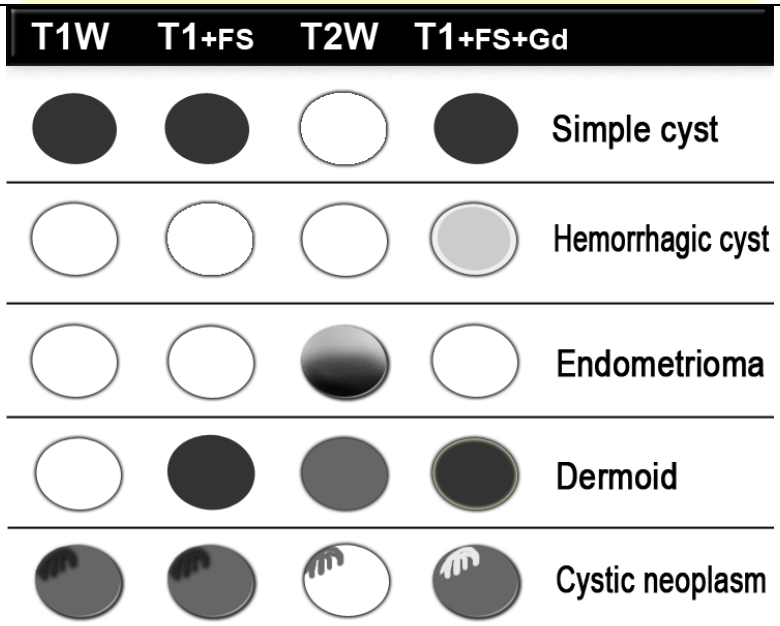
Any other cyst *possibly malignant*



Low Risk and High Risk:
Surgical resection by oncologic gynaecologist who may request prior imaging-based staging

MRI protocol

1. **T2W hi-res no fatsat** at least 2 planes for anatomy
2. **T1W no fatsat** or opposed-phase
3. **T1W with fatsat**
4. **PDW or T1W** extending to upper abdomen
5. **T1W with fatsat + Gd**
6. **DWI**



Non-Ovarian Cystic Lesions of the Pelvis

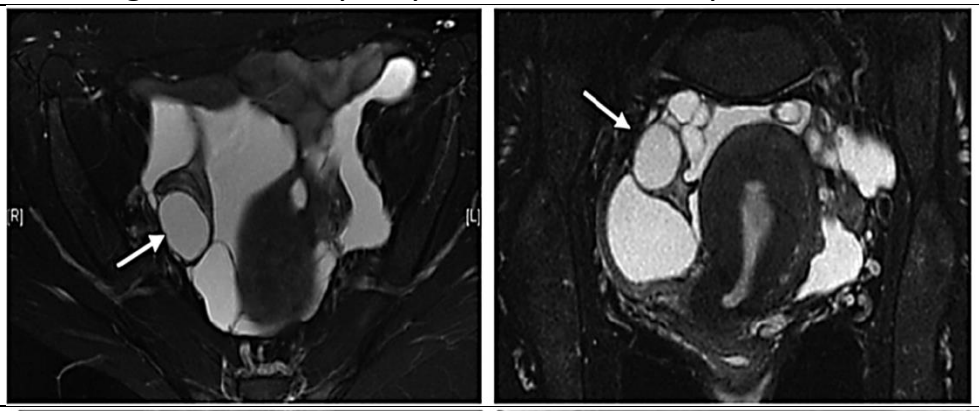
Intraperitoneal	
Peritoneum	Peritoneal inclusion cyst, paraovarian cyst
Appendix	Appendiceal mucocele (retention cyst, mucosal hyperplasia, cystadenoma, cystadenocarcinoma)
Fallopian tubes	Hydrosalpinx, hematosalpinx, pyosalpinx
Uterus	Degenerating leiomyoma, cystic adenomyosis, unicornuate uterus with an obstructed horn
Extraperitoneal	
Presacral space	Spinal meningeal cyst, retrorectal cyst
Vascular and lymphatic system	Lymphocele, cystic degeneration of lymph nodes, pelvic lymphangioleiomyomatosis, cystic lymphangioma, pelvic hemangioma
Both intra- and extraperitoneal	Pelvic abscess, hematoma, bladder diverticulum

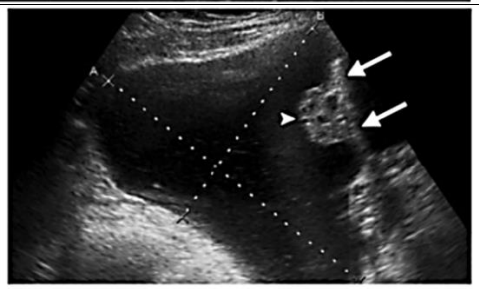
1) Peritoneal Inclusion Cyst

- Multilocular inclusion cyst
- is a nonmalignant, reactive, mesothelial proliferation of peritoneal cells that results from insult to the peritoneum.
- The most common peritoneal insults are endometriosis, pelvic inflammatory disease, previous abdominal or pelvic surgery, and trauma

Imaging findings:

- Unilateral or bilateral cystic masses
- Attenuation or signal intensity of fluid
- NO enhancing solid components
- NO entrapped ovaries but ovaries may be surrounded by inclusion cyst.
- Hemorrhage occasionally may be seen within a cyst.





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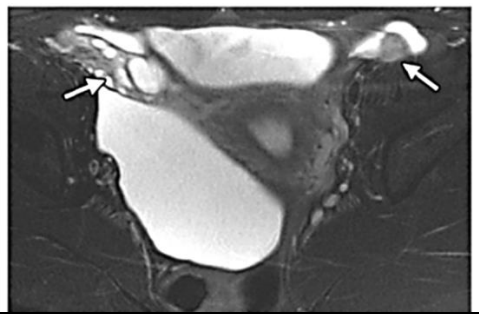
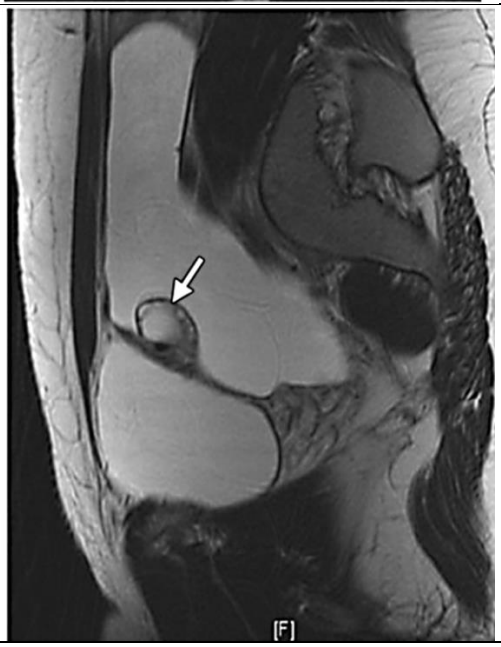


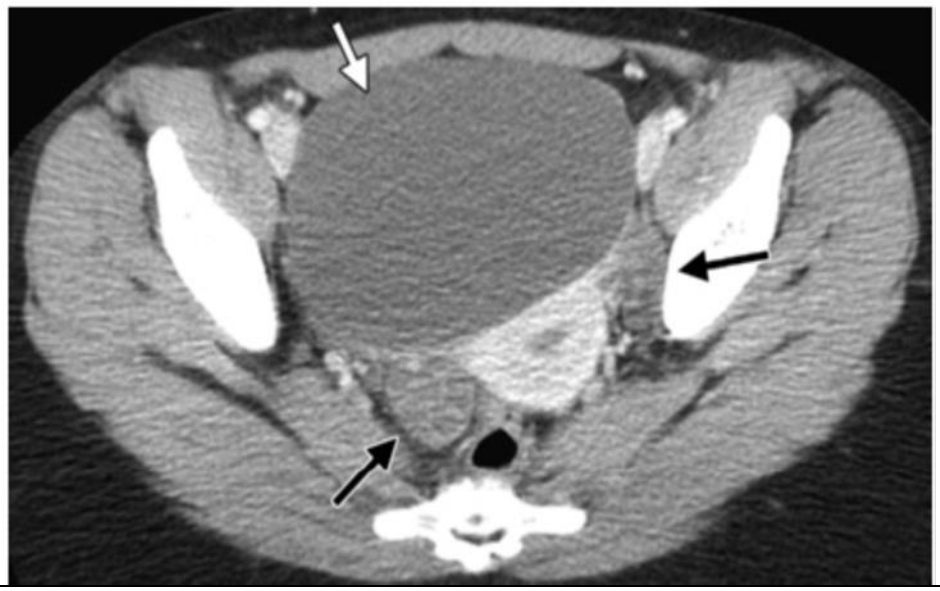


2) Paraovarian Cysts

- account for 10%–20% of all adnexal masses.
- They arise from the mesosalpinx—the superior, free border of the broad ligament—which invests the fallopian tube.
- occur over a wide age range, more 3rd and 4th decades
- Because they arise from the broad ligament or fallopian tube, the ipsilateral ovary is not affected and maintains its normal configuration.
- can be very small to large enough to fill the pelvis;
- average size at diagnosis is 8 cm
- bilateral cysts and multiple unilateral cysts have been documented

Imaging findings:

- A round or oval cystic structure is seen in close proximity to, but separate from, the ovary
- A well-defined homogeneous structure,
- If the cyst is complicated by torsion or hemorrhage, it may demonstrate high signal intensity on T1, have thick walls.



Female Genital System

Fallopian Tube

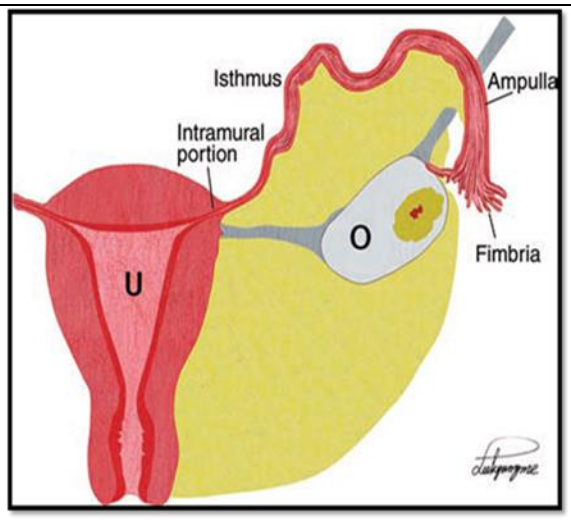
❖ Embryologic Development:

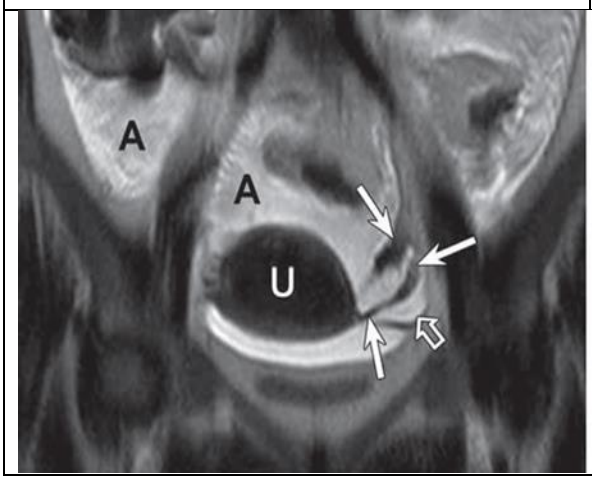
- During the 5th to 6th weeks of gestation, the paired paramesonephric ducts form from the coelomic epithelium.
- The cranial portions of the paramesonephric ducts develop into the fallopian tubes, and the caudal portions fuse to form the uterus.
- The cranial end of the fallopian tube remains open, thereby communicating with the peritoneal (coelomic) cavity, with multiple invaginations of the free edge forming the fimbriae.
- The caudal end communicates with the uterine cornua.

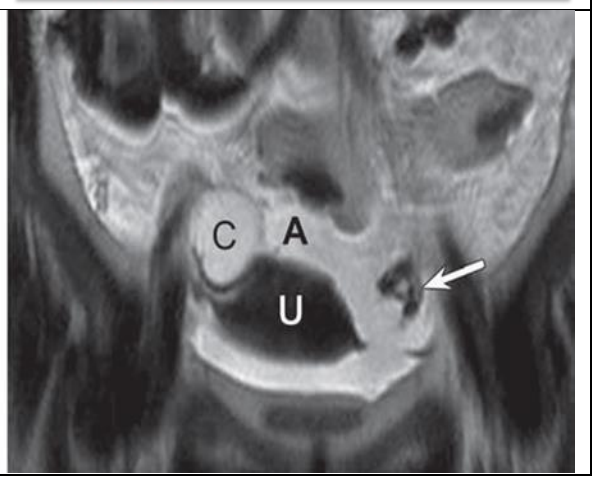
❖ Anatomy of Fallopian tube:

4 segments:

1) The interstitial portion, which traverses the myometrium (1 cm long)
2) The isthmic portion, which courses within the broad ligament (2–3 cm long)
3) The ampullary portion, which is adjacent to the ovary
4) The infundibulum at the fimbriated end







Tubal Occlusion

- Tubal spasm
- Prior surgery
- Tubal Infection
- Granulomatous salpingitis due to tuberculosis
- Parasitic infection
- Intraluminal endometriosis
- Congenital atresia of the fallopian tubes.

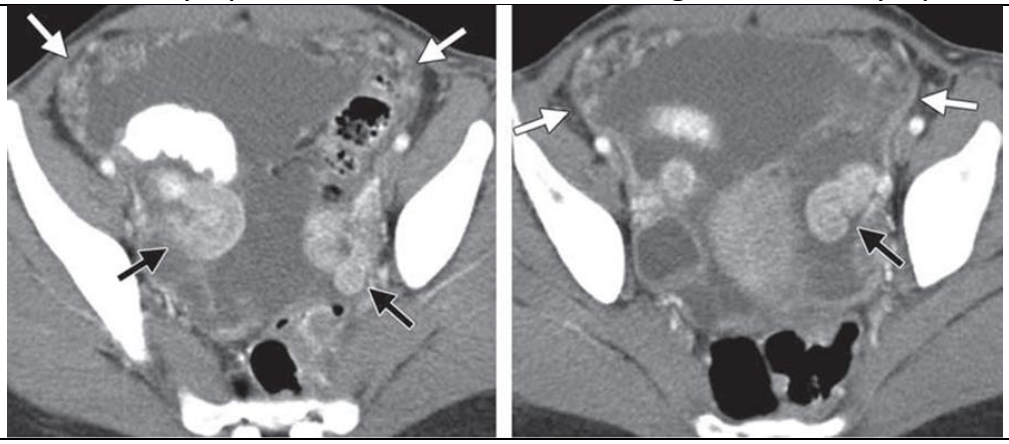
Congenital Anomalies of the Fallopian Tubes

- Aplasia
- Hypoplasia
- Accessory ostia.
- Congenital diverticula.
- Diethylstilbesterol exposure in utero increases the risk of hypoplastic and strictured fallopian tubes.

Tubal Tuberculosis

Infection of the genital tract is usually accompanied by peritoneal infection:

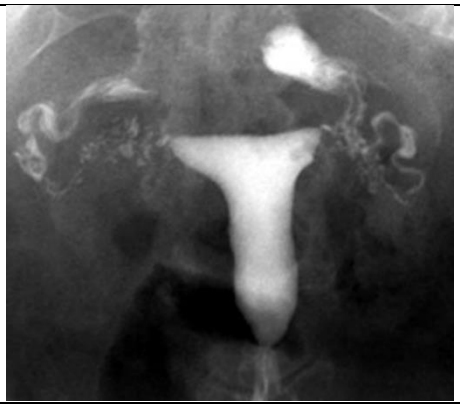
- Bilateral thickening and intense enhancement of the fallopian tubes
- Loculated ascites
- Omental and mesenteric soft-tissue infiltration.
- Peritoneal thickening and nodularity are present.
- Tuberculous lymphadenitis manifests as enlarged necrotic lymph nodes



Salpingitis Isthmica Nodosa (SIN)

- An inflammatory process within the fallopian tube.
- The exact cause of this process is unknown, but associations with pelvic inflammatory disease, infertility, and ectopic pregnancy have been reported.

- Tubal irregularity
- Smalll subcentimetric outpouchings or diverticula from the isthmic portion of the tube



Pelvic Inflammatory Disease (PID)

- Pelvic inflammatory disease is one of the most common causes of tubal and peritubal damage.
- Pelvic inflammatory disease occurs when an ascending bacterial infection causes inflammation of the upper female genital tract, including the endometrium, fallopian tubes, and ovaries.

Causative Organism:

- PID usually results from ascending infection by Neisseria gonorrhoeae or Chlamydia trachomatis

Risk Factors:

- Young age,
- Multiple sex partners
- High coital frequency
- Low socioeconomic status
- Douching
- Use of an intrauterine device (particularly during the first few months after insertion) as well as other forms of pelvic instrumentation.

Complications:

- Tubal damage, scarring, and occlusion.
- Infertility due to fallopian tube occlusion (tubal factor infertility) that will occur in 8% of patients after a single episode of PID, with an increase in risk to 20% after two episodes of PID and to 40% after three episodes
- Ectopic pregnancy (6 fold higher risk)
- Subsequent episodes of PID
- Chronic pelvic pain

Patterns of PID:

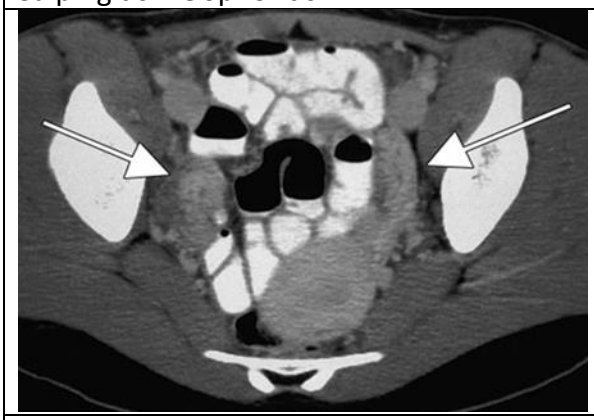
- **Early PID**
- **Peritubal adhesions**
- **Hydrosalpinx**
- **Pyosalpinx**
- **Tuboovarian abscess**
- **Involvement of Adjacent Structures in PID**
- **Fitz- Hugh-Curtis Syndrome**

a) Early PID

Imaging findings:

- Subtle and their interpretation is based on the clinical findings.
- **Mild pelvic edema**: thickening of the uterosacral ligaments and haziness of the pelvic fat with obscuration of the pelvic fascial planes.
- **Salpingitis**: thickening and enhancement.
- **Oophoritis:** Enlarged and abnormally enhancing ovaries, which may demonstrate a polycystic appearance
- **Endometritis**: abnormal endometrial enhancement and fluid within the endocervical canal
- **Cervicitis:** enlarged with an abnormally enhancing endocervical canal.
- Fluid in the cul-de-sac, may be observed.
- Periovarian stranding and enhancement of the adjacent peritoneum are common associated findings.

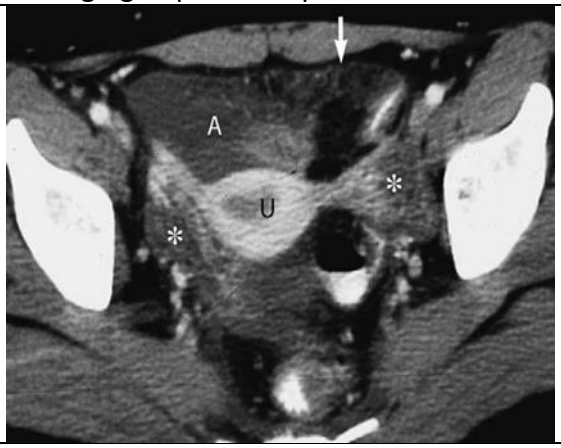
Salpingitis + Oophoritis



Cervicitis + pericervical inflammation

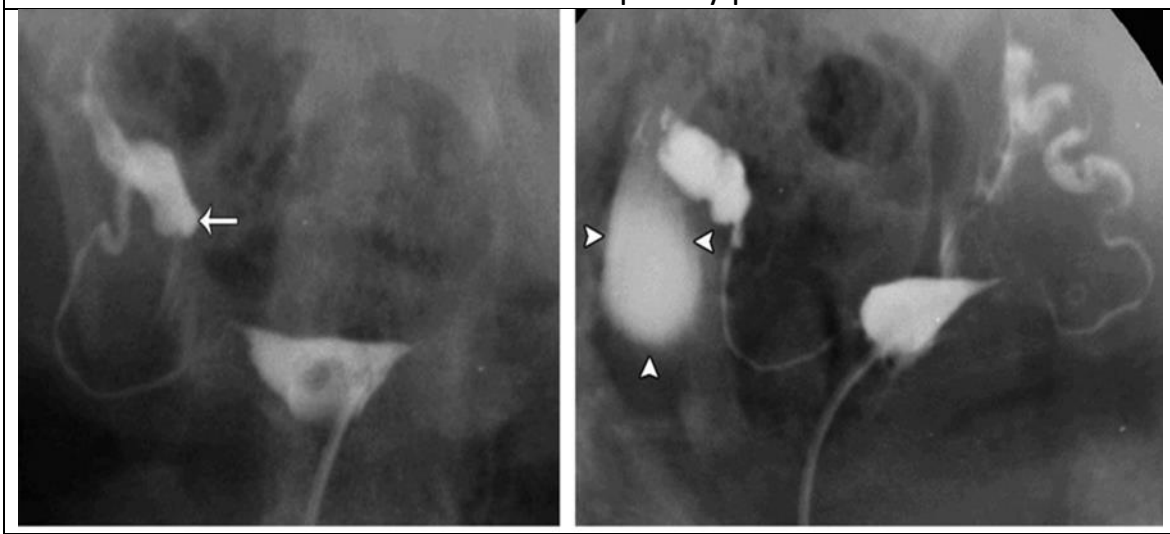
Endometritis + Fluid

Smudging of pelvic fat planes + Fluid



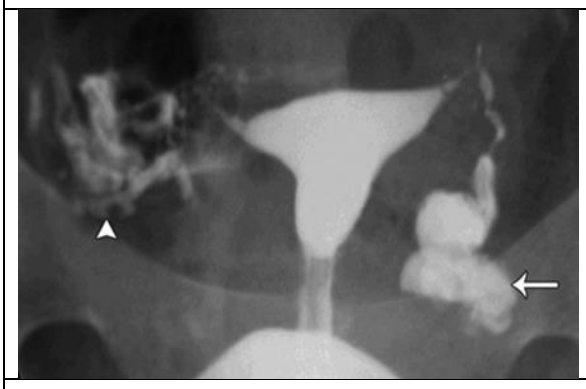
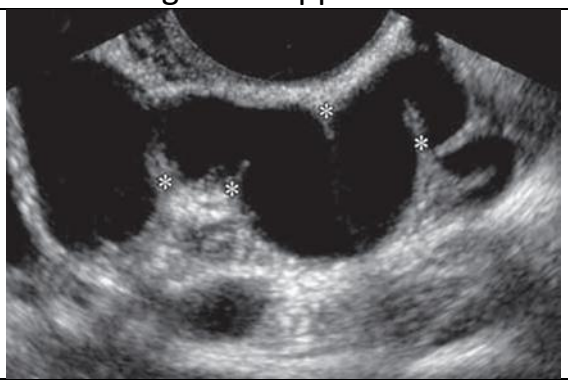
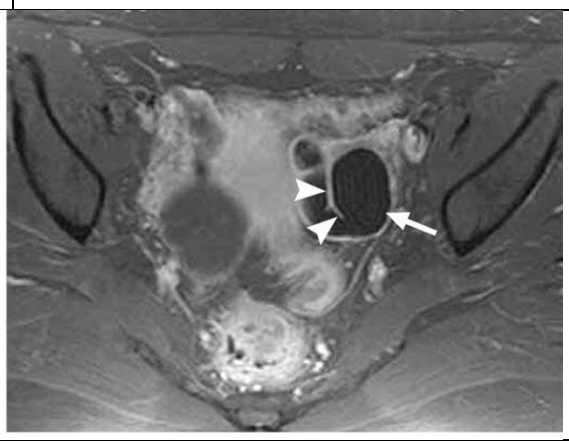
b) Peritubal Adhesions:

- Another sequela of PID is scarring in the peritoneal cavity surrounding the fallopian tube.
- HSG: Peritubal adhesions prevent contrast material from flowing freely around the bowel loops and most commonly manifest as loculation of the contrast material around the ampullary portion of the tube



c) Hydrosalpinx

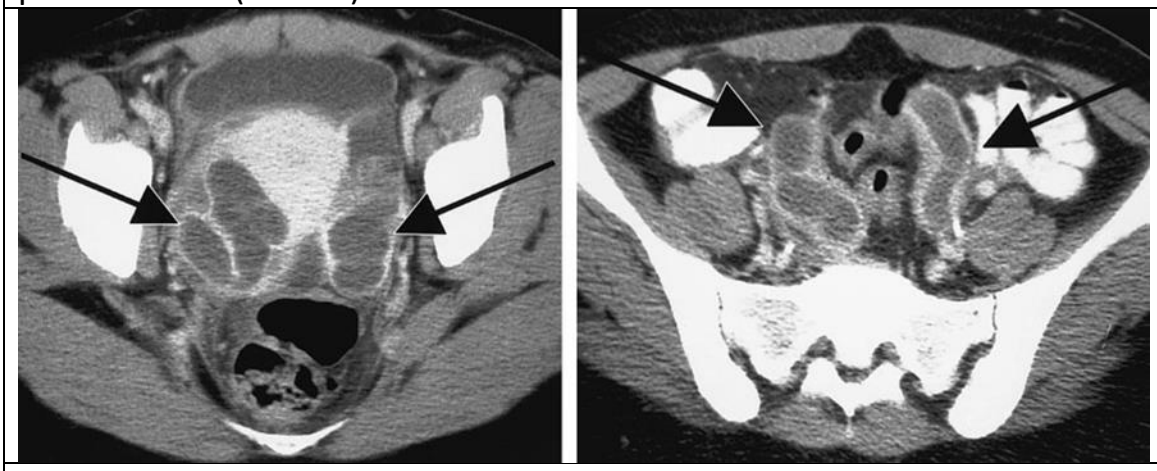
- Hydrosalpinx is a common adnexal lesion.
- Distal tubal occlusion by:
    - Pelvic inflammatory disease
    - Endometriosis
    - Fallopian tube tumor
    - Tubal pregnancy
    - Tubal ligation
- The most common cause of distal tubal occlusion and hydrosalpinx is pelvic inflammatory disease.

HSG: Fallopian tube dilated + Absence of intraperitoneal spillover of contrast material.	US: Adenexal S-shaped Tortuous dilated anechoic tubular structure + incomplete septae along the tubal wall => Cogwheel appearance.
	
MRI: Left Adenexal S-shaped Tortuous tubular structure with hyperintense T2 signal (arrow) + incompletely effaced mucosal and submucosal plicae (arrowheads) along the tubal wall.	+C: Marginal enhancmement.
	

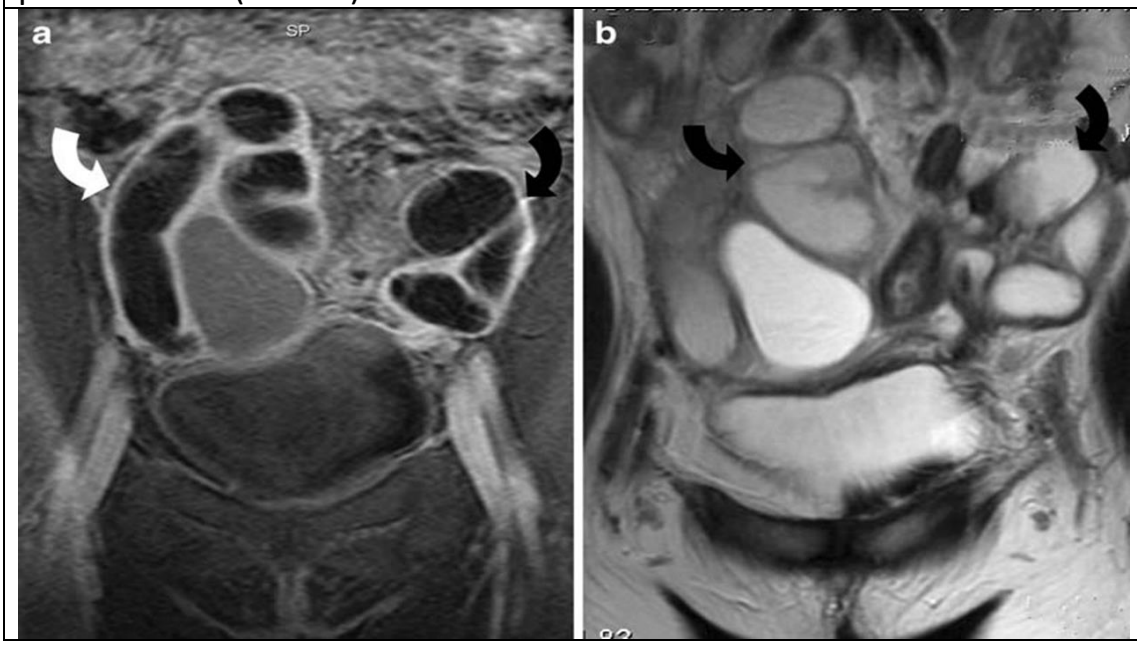
d) Pyosalpinx

- On MR images, both hydrosalpinx and pyosalpinx appear as dilated, fluid-filled, tubular structures.
- However, pyosalpinx often cannot be reliably differentiated from hydrosalpinx on MR images
- With pyosalpinx, the wall of a dilated fallopian tube may be thickened,
    - T1: variable SI
    - T2: heterogeneous SI

CT: Dilated, thick walled, enhancing fallopian tubes containing complex purulent fluid (arrows).



MRI: Dilated, thick walled, enhancing fallopian tubes containing complex purulent fluid (arrows).



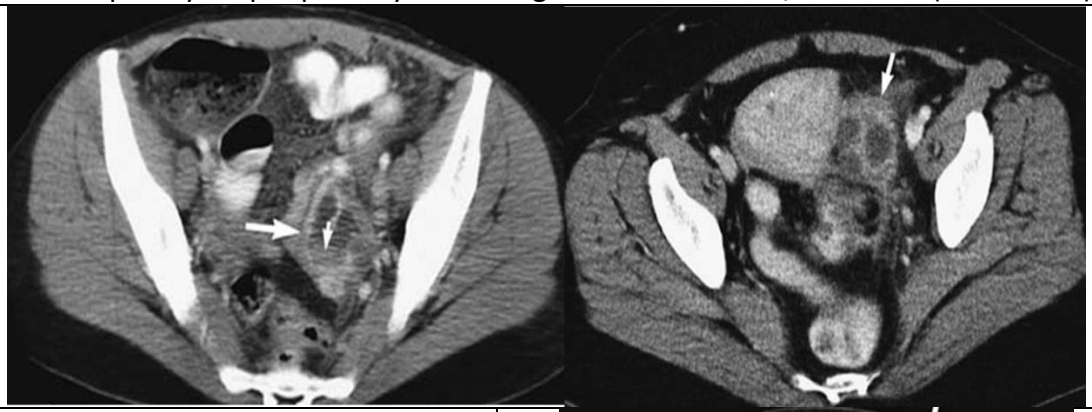
e) Tuboovarian Abscess (TOA)

- TOA result from pelvic inflammatory disease (PID).
- TOA most commonly occurs in women in the reproductive ages.
- The two most common bacteria are Neisseria gonorrhoeae and Chlamydia trachomatis.

Imaging findings:

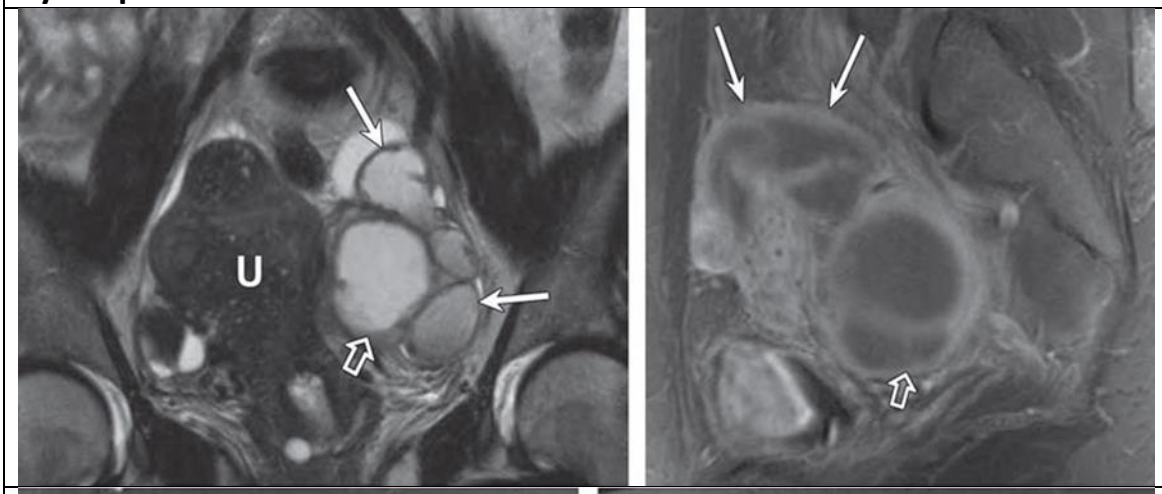
- Complex heterogenous fluid-containing adnexal mass.
- Contain irregular inner contours, internal septa, gas bubbles (most specific signs), fluid, or a fluid-debris level.
- Anterior displacement of the broad ligament because of the posterior position of the mesovarium may allow differentiation of a tuboovarian abscess from a pelvic abscess of other origin
- Thick enhancing wall
- Mesh-like strands in the pelvic fat planes are almost always found because of dense pelvic adhesions or fibrosis
- Peritoneal enhancement, especially in the lesser pelvis, and small amounts of ascites are signs of associated peritonitis

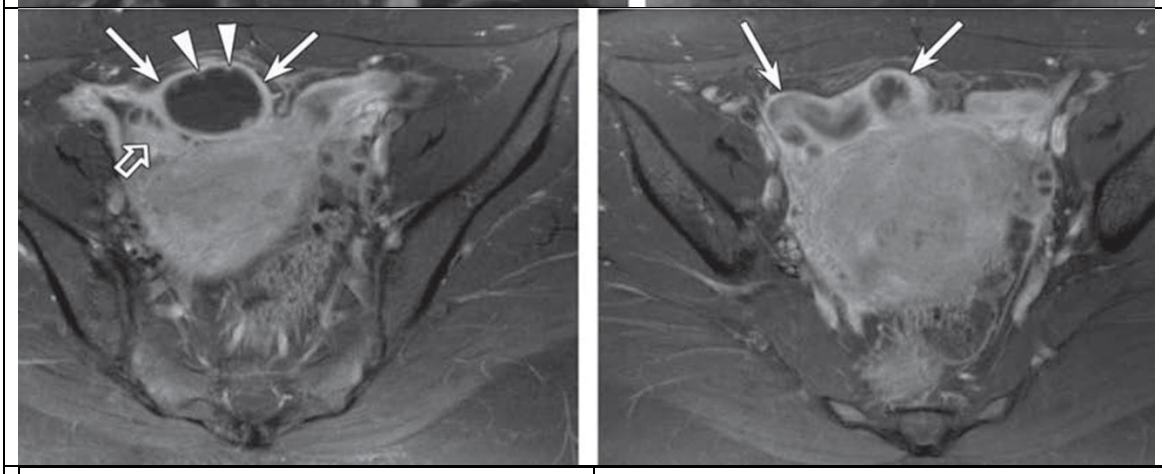
TOA= Complex cystic peripherally enhancing lesion with a fluid/fluid level (arrowhead).



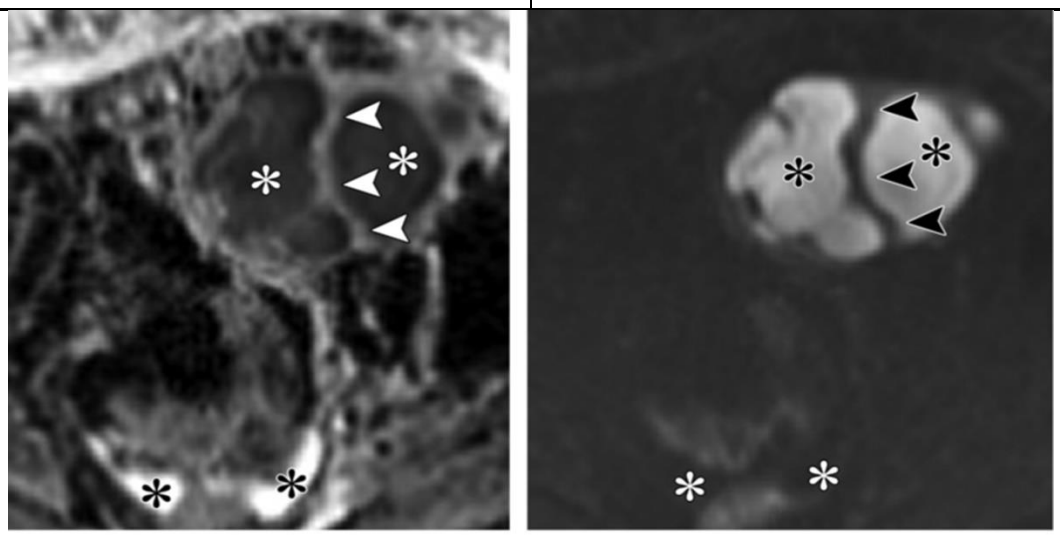
Peritonitis associated with TOA:
Ascites + linear peritoneal enhancement (small arrows) + netlike involvement of the pelvic fat and the omentum (arrow)

Pyosalpinx and Tubo-ovarian abscess



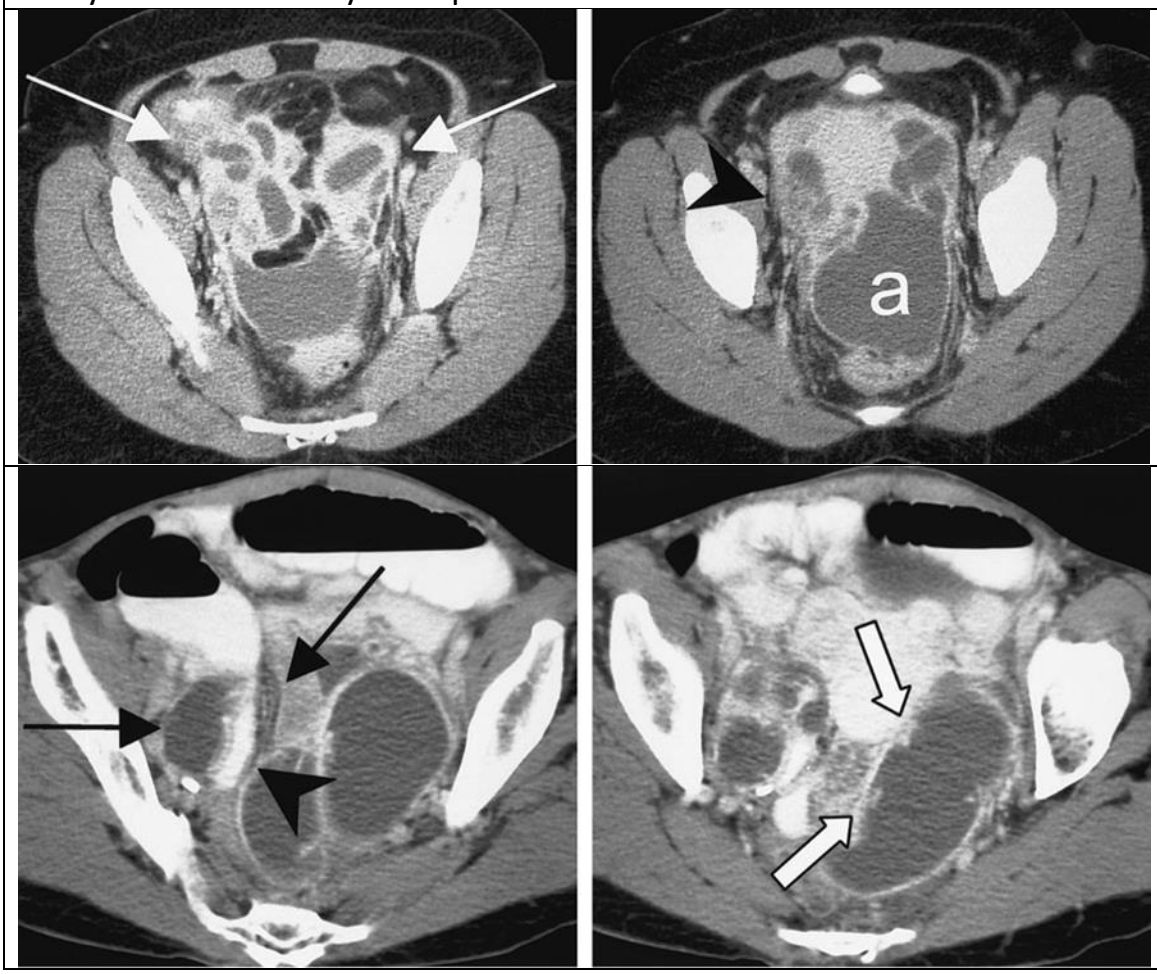


Low ADC | Restricted DWI



f) Involvement of Adjacent Structures in PID

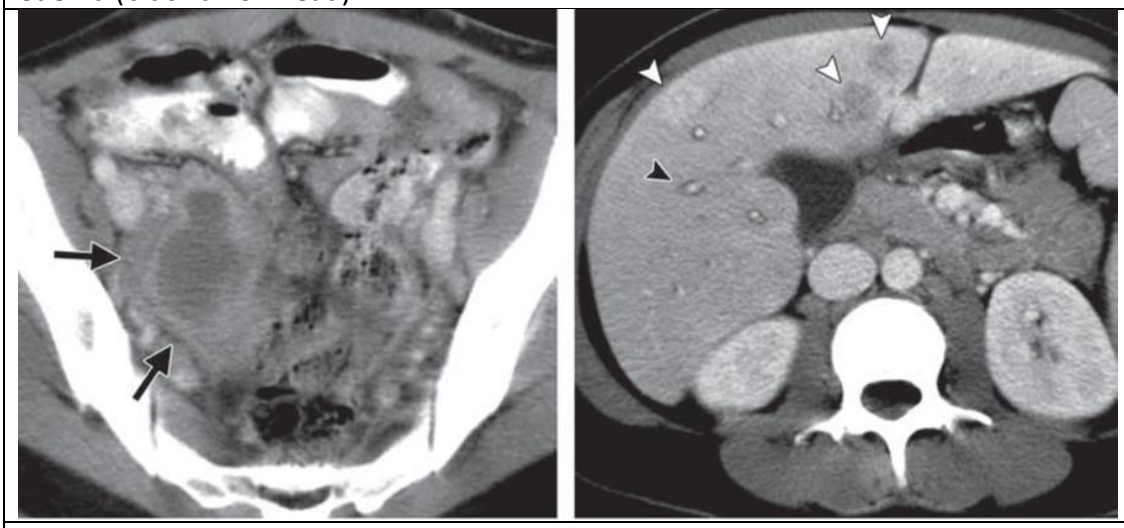
- Pelvic small bowel loops may be dilated due to:
    - Adynamic ileus resulting from adjacent inflammation
    - Mechanical obstruction resulting from the inflamed, enlarged, and tethered pelvic structures.
- Colonic wall thickening, ileus, or obstruction may also be seen
- Functional or mechanical obstruction of the ureters may result in hydroureter and hydronephrosis.



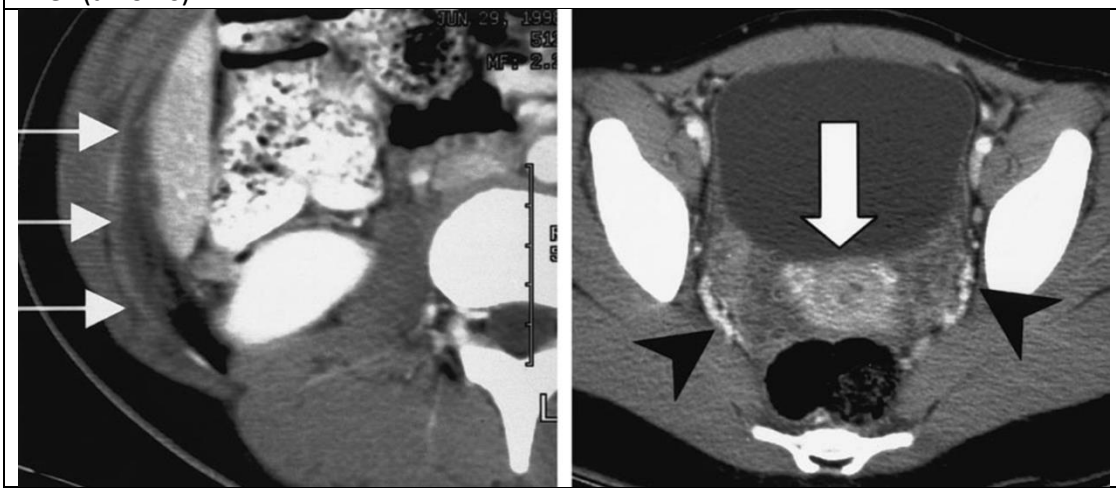
g) Fitz- Hugh-Curtis Syndrome

- Bacteria spread by means of direct extension along the right paracolic gutter or through the lymphatic system, causing inflammation of the right upper quadrant peritoneal surfaces and the right lobe of the liver.
- **Perihepatitis**: thickening and enhancement of the anterior liver capsule.
- **Inflammation of the Glisson capsule** can cause subcapsular and periportal geographic areas of perfusional variation.
- **Gallbladder wall thickening** may be present.
- Fluid and inflammatory stranding can be seen to extend from the pelvis via the paracolic gutter to the right upper quadrant.
- There may be peritoneal septa and loculated perihepatic fluid

Subcapsular and periportal perfusional variation (white arrowheads) and periportal edema (black arrowhead)



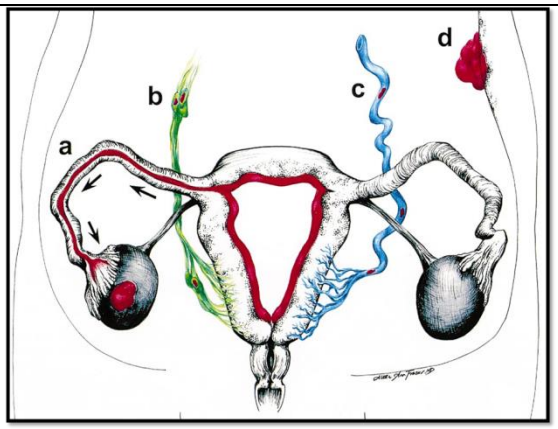
Inflammatory stranding along the right paracolic gutter and inferior right lobe of the liver (arrows).



Endometriosis

- A condition defined by the presence of endometrial glands and stroma outside the uterus.
- This condition almost exclusively affects women during their reproductive years.
- 30%–50% of women with endometriosis are infertile
- 20% - 50% of infertile women have endometriosis

The potential mechanisms of endometriosis pathogenesis, including:
(A) Retrograde Menstruation
(B) Lymphatic Spread
(C) Hematogenous Spread
(D) Coelomic Metaplasia



<u>3 patterns:</u>

a) Ovarian Endometrioma
b) Pelvic Endometriotic Implants:
   - Anterior Compartment
   - Middle Compartment
   - Posterior Compartment
c) Pelvic Adhesions:
   - Posterior Compartment
   - Anterior Compartment

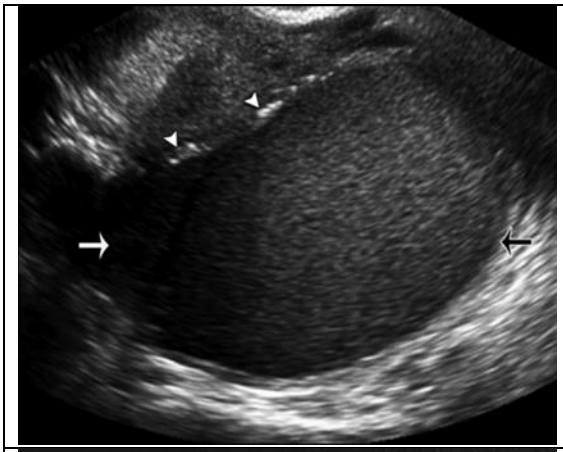
Most Common Sites for Endometriotic Implants and Adhesions

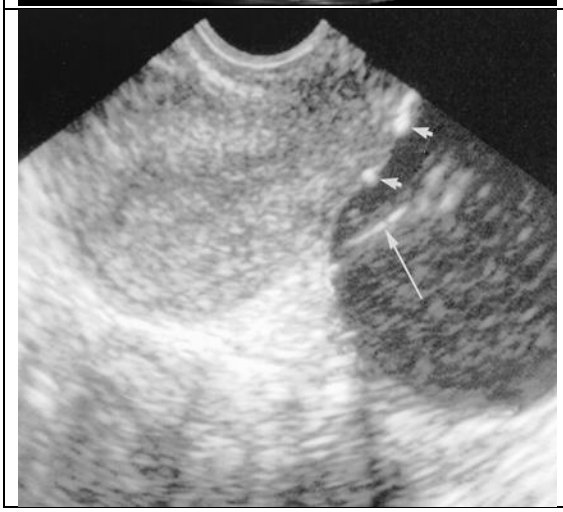
Location	Implants (%)	Adhesions (%)
Ovaries	76	39
Anterior and posterior cul-de-sac	69	13
Posterior broad ligament	47	43
Uterosacral ligament	36	7
Uterus	11	3
Fallopian tubes	6	26
Sigmoid colon	4	12
Ureter	3	2
Small intestine	0.5	3

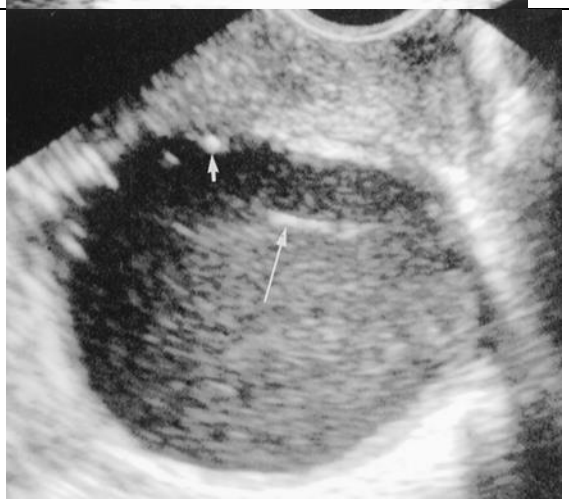
a) Ovarian Endometrioma

US: Adenexal cyst with:

- Faint internal echoes
- Highly echogenic wall foci
- may be unilocular or multilocular.
- Thin or thick septations







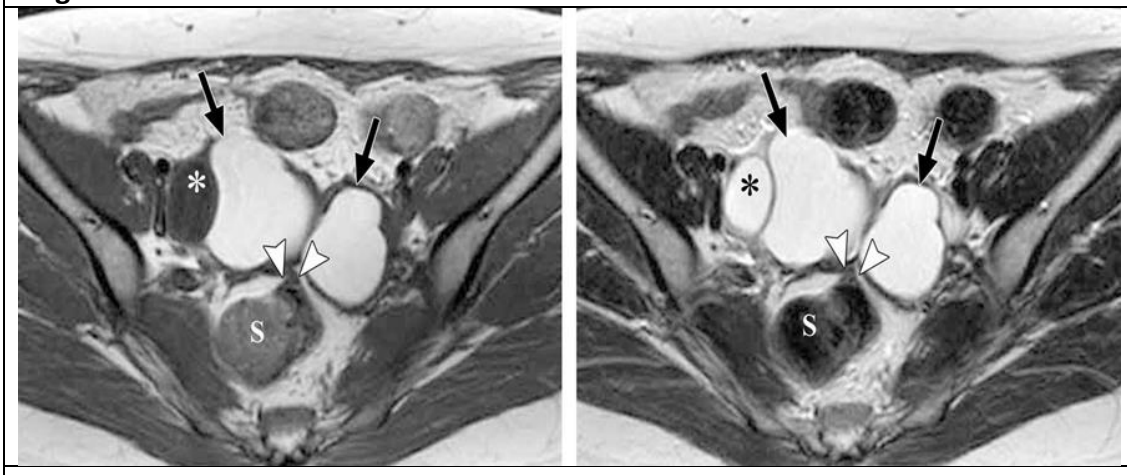
MRI: Adenexal cyst with thickened walls

(A) high SI on both T1 and T2 WI

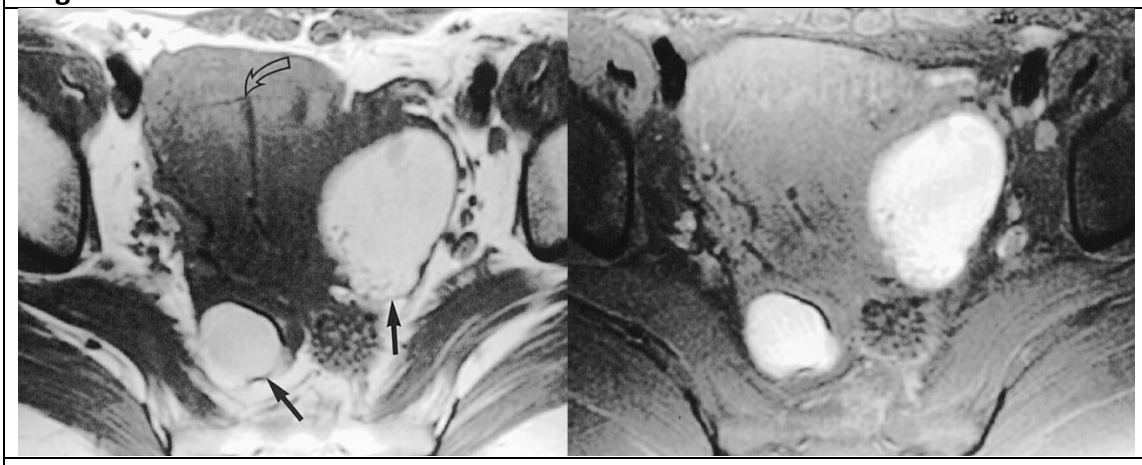
or

(B) high SI on T1 WI and low SI on T2 WI (shading)

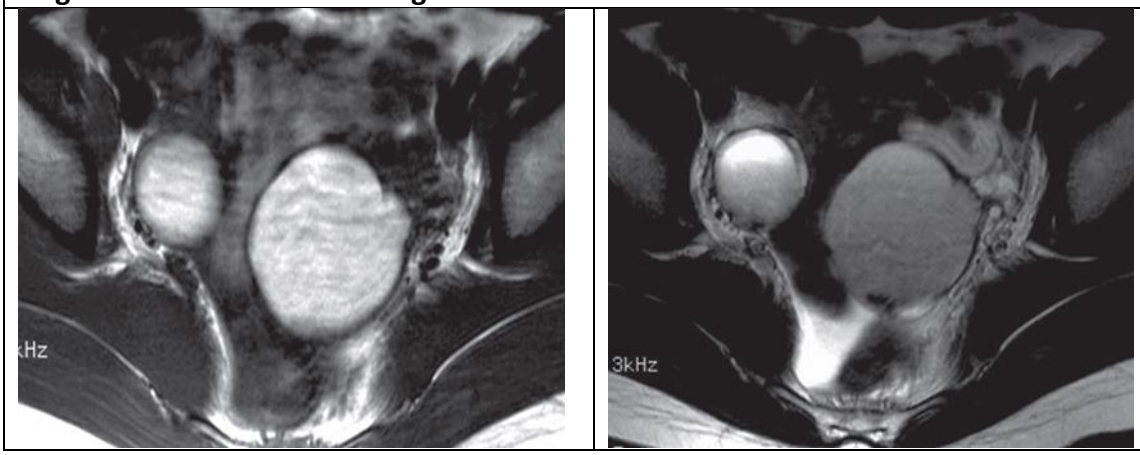
Bright T1 and T2



Bright T1 and T1 FS



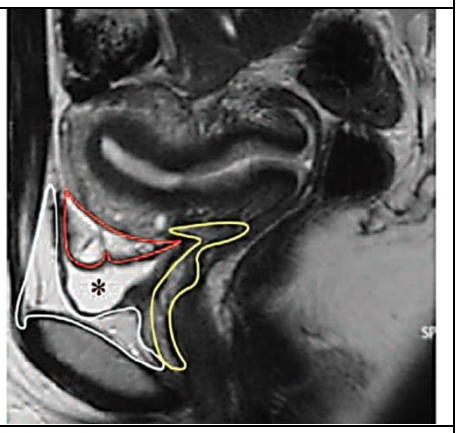
Bright T1 and low T2 = Shading



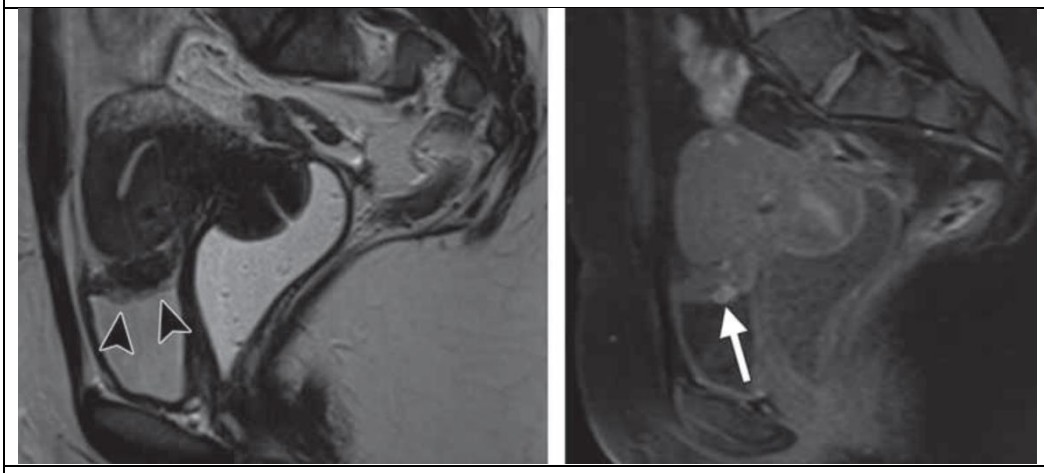
b) Pelvic Endometriosis

i) Anterior Compartment

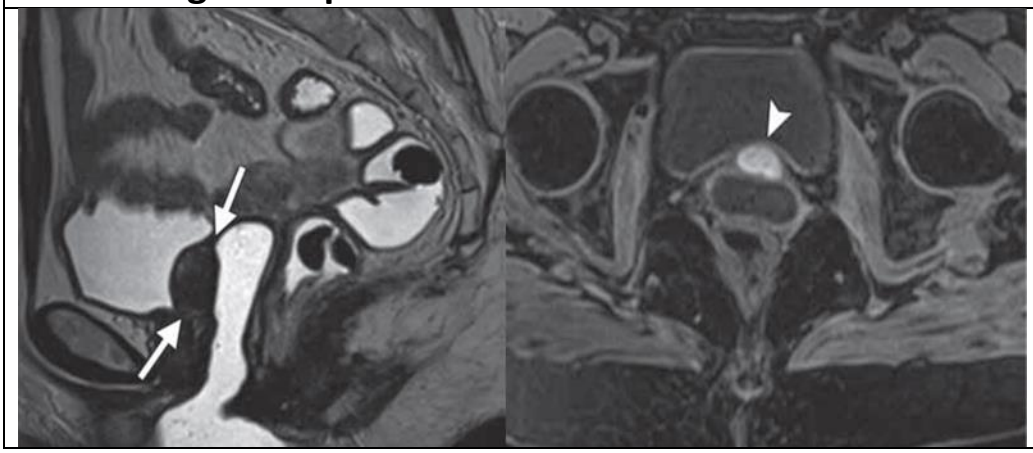
- Bladder (detrusor muscle) (*)
- Ureter.
- Prevesical space (White outline)
- Vesico-uterine pouch (Red outline)
- Vesico-vaginal septum (yellow outline)



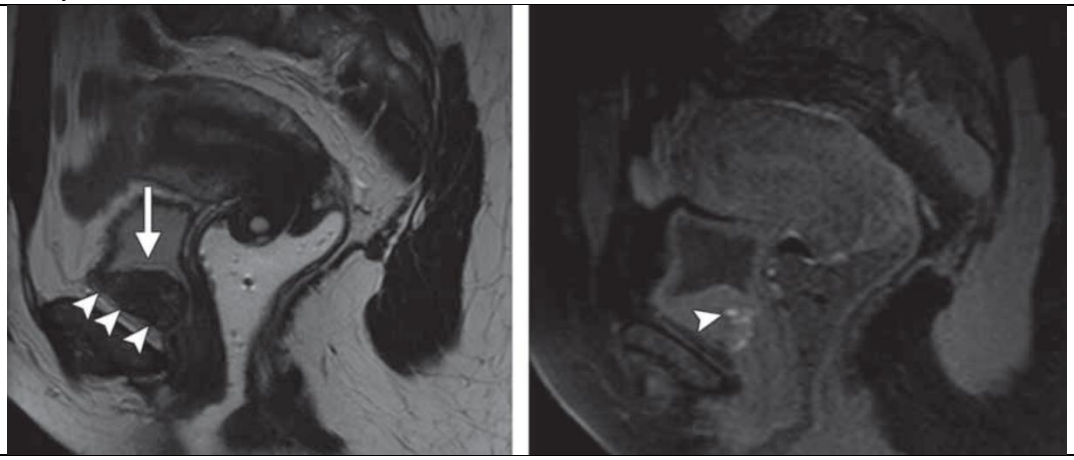
Vesico-uterine Pouch



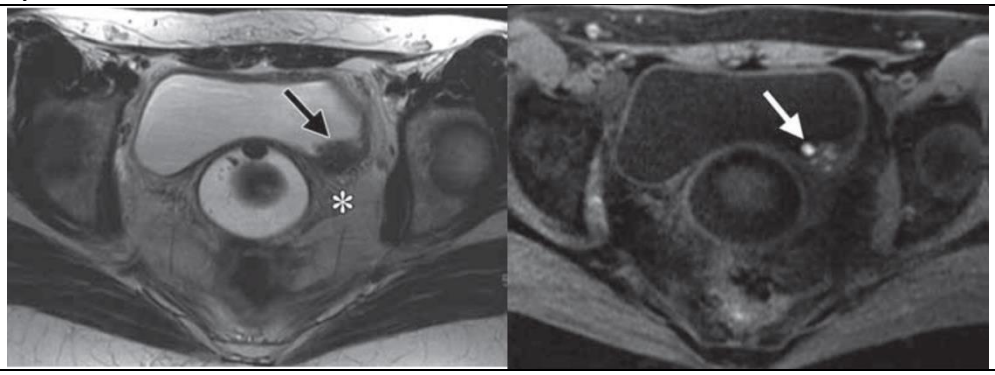
Vesico-vaginal Septum



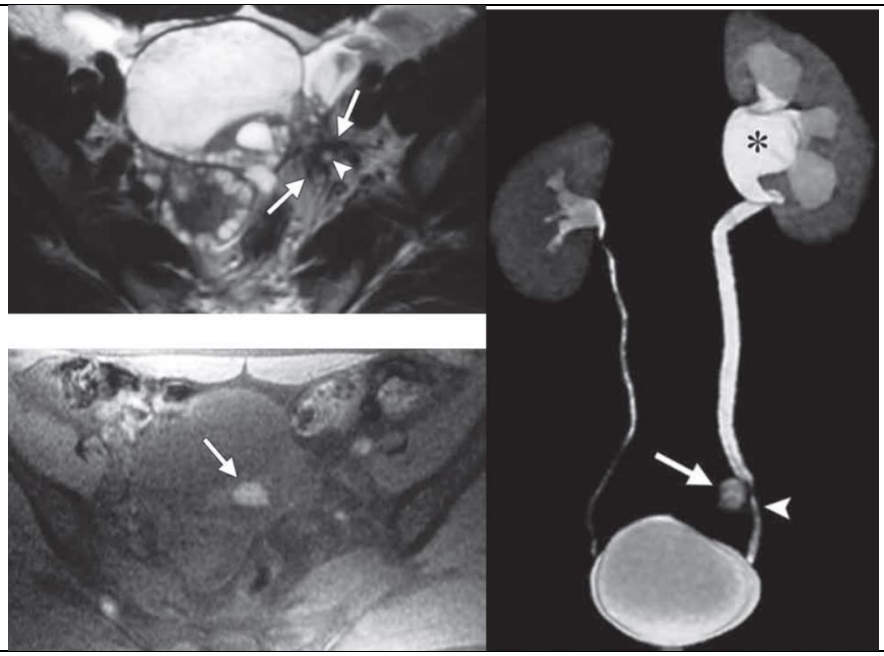
Urinary Bladder Anterior wall



Urinary Bladder Posterior wall



Ureteral Endometriosis



ii) Middle Compartment

- Uterus
- Ovaries
- Fallopian tubes
- Uterine ligaments.

❖ *Tubal Endometriosis:*

1) Serosal and subserosal:

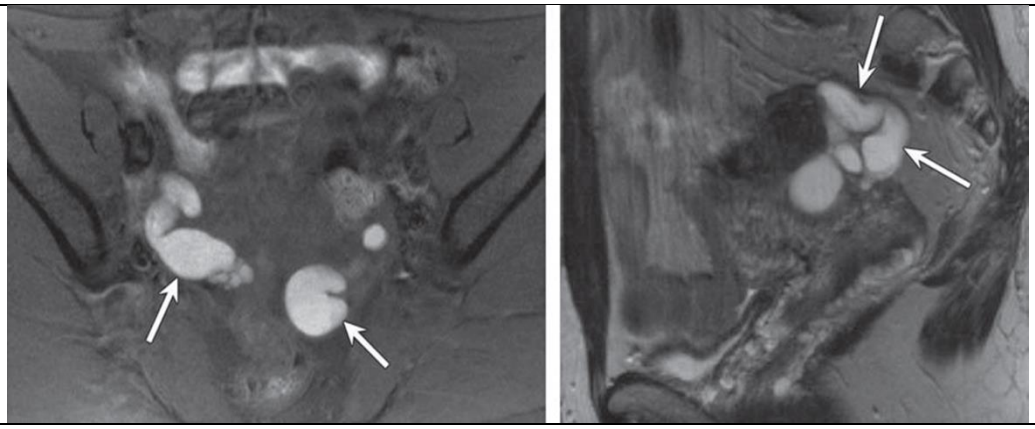
- The most common type.
- cause repeated bouts of intralesional hemorrhage and fibrosis,
- Resultant formation of peritubal adhesions and, thus, ***hydrosalpinx***.

2) Intraluminal:

- Less common type of tubal endometriosis
- Ectopic implantation of endometrium on the mucosal surface of the tube lumen.
- Cyclic hemorrhage of the implants can cause distention of the fallopian tube with blood (ie, ***hematosalpinx***).

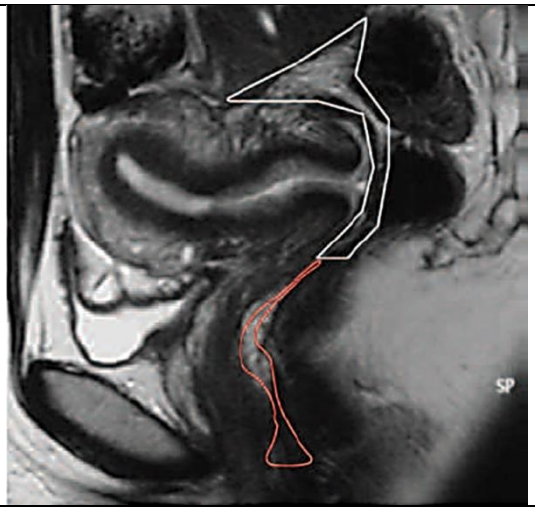
Imaging findings:

- T1: Hyperintense tubal fluid, with or without evidence of endometriosis elsewhere in the pelvis, is suggestive of hematosalpinx associated with endometriosis.
- T2: SI within the fallopian tube generally is very high relative to the typical SI of an endometrial cyst, which displays moderate to marked shading due to T2 shortening.
- Hematosalpinx has been reported to be an indicator of pelvic endometriosis in certain patients, and it may be the only imaging finding indicative of endometriosis

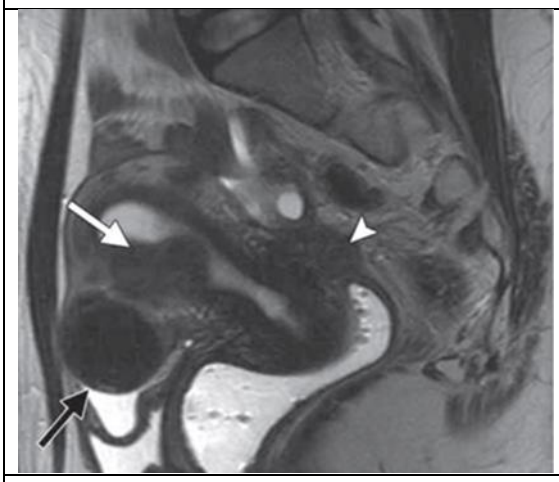


iii) Posterior Compartment

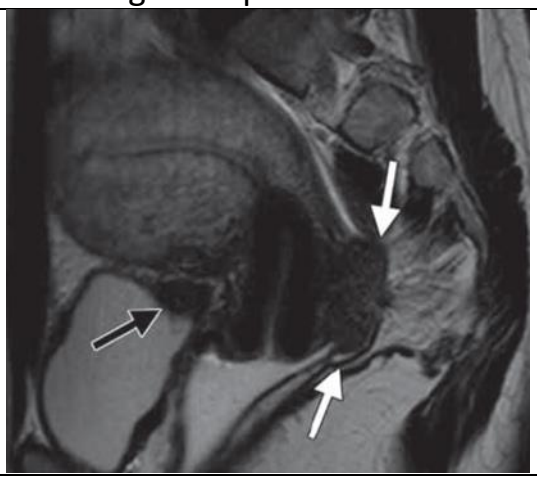
- Rectovaginal pouch (White outline)
- Retrocervical area–torus uterinus
- Uterosacral ligaments
- Posterior vaginal fornix
- Rectovaginal septum (red outline)
- Rectum.



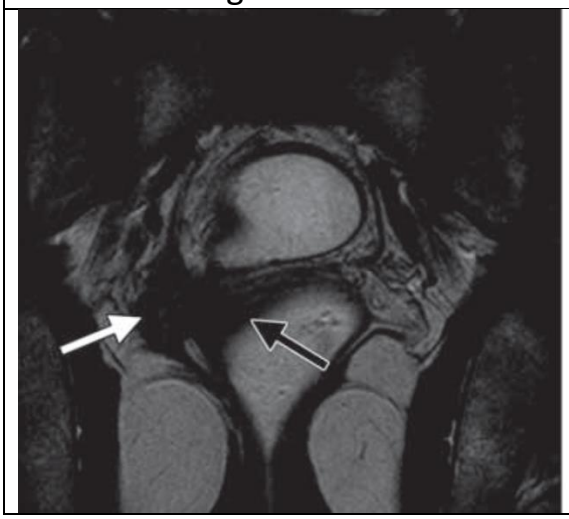
Retrocervical Endometriosis

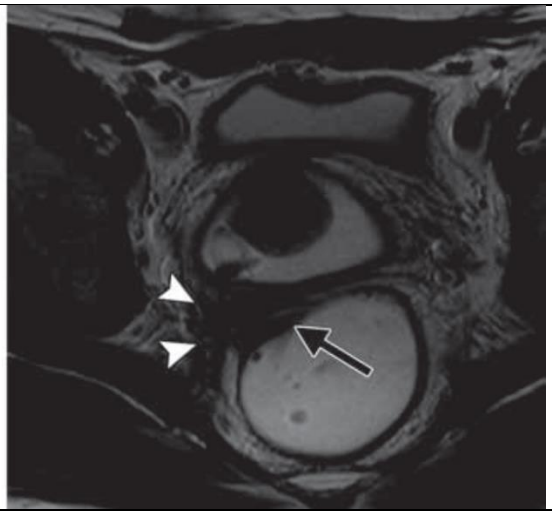


Rectovaginal septum



Uterosacral Ligament Endometriosis





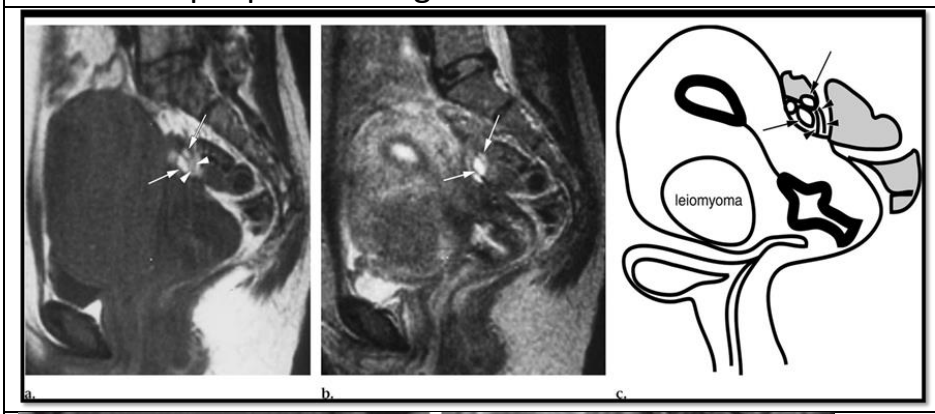
c) Pelvic Adhesions

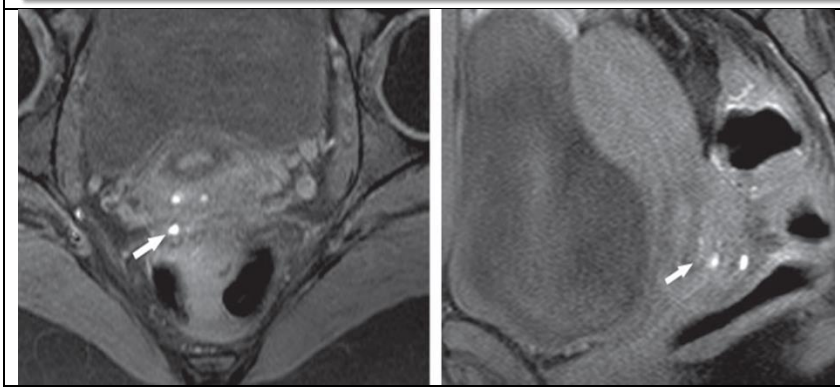
❖ Posterior Cul-de-Sac Obliteration:

- Clinical presentation includes dysmenorrhea, dyspareunia, dyschezia, and infertility, but the diagnosis of DIE is difficult and can be delayed.

- Solid deep endometriotic implant lesions with deep infiltration demonstrate:
- Low to intermediate SI on T1 and T2 WIs and enhancement, corresponding to the abundant fibrous tissue seen in these lesions.
- Punctate foci of high SI represent regions of hemorrhage surrounded by solid fibrotic tissue

- Retroflexed uterus
- Elevated posterior vaginal fornix
- Intestinal tethering and/or
- Tethered appearance of the rectum (*) in direction of uterus
- Faint strands between uterus and intestine
- Fibrotic plaque covering serosal surface of uterus.

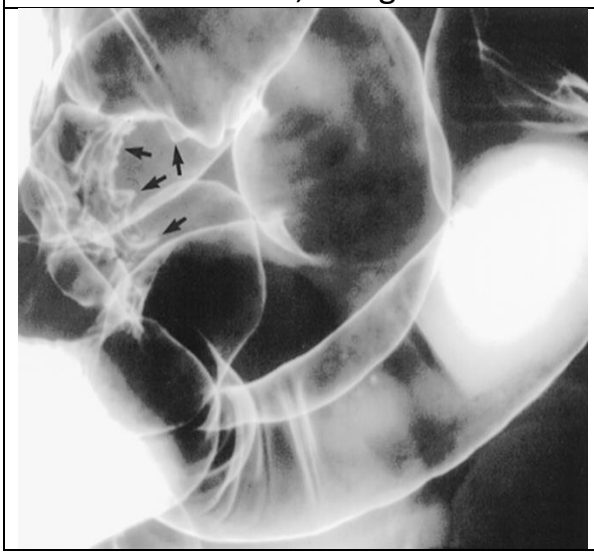


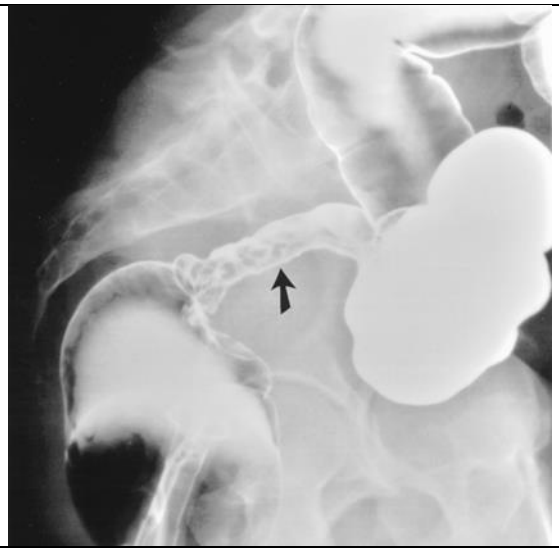


d) Extra-Pelvic Endometriosis

1) Gastrointestinal Tract

- 12%–37% of patients with endometriosis
- It most commonly affects those segments of bowel in the dependent portion of the pelvis.
- The most commonly affected areas in decreasing order of frequency are the rectosigmoid colon, appendix, cecum, and distal ileum.
- The implants are usually serosal but can eventually erode through the subserosal layers and cause marked thickening and fibrosis of the muscularis propria.
- An intact overlying mucosa is almost always present, since the implanted tissue only rarely invades through to the mucosa.
- Inflammatory response to cyclic hemorrhage can lead to adhesions, bowel stricture, and gastrointestinal obstruction.





2) Genitourinary Tract:

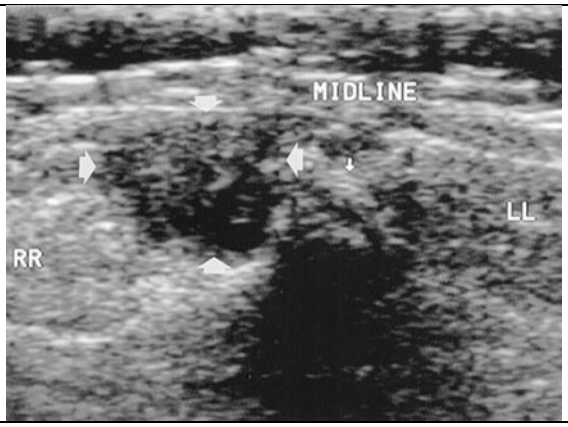
- 20% of patients with endometriosis.
- The bladder is the most frequently involved organ, followed by the ureters.
- The distal ureter is the most common ureteral segment involved.
- Only scattered cases of renal or urethral involvement have been reported

3) Chest

- Well-documented endometriosis of the chest, thoracic endometriosis syndrome (TES), is uncommon, and the diagnosis is usually established on clinical grounds.
- The two theories entertained for the development of TES are microembolization and peritoneal-pleural migration.
- Radiographic findings include pneumothorax, hemothorax, and lung nodules.

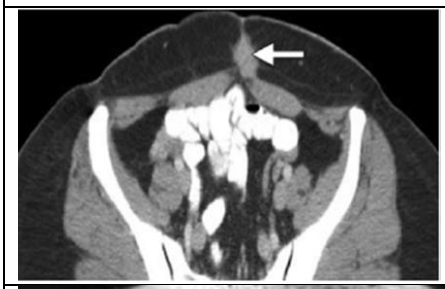
4) Cutaneous Tissues

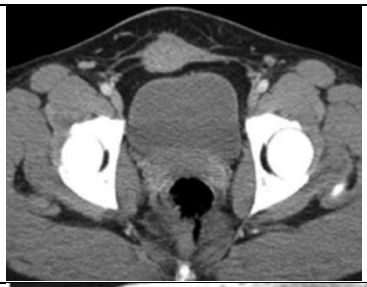
- Endometriosis can occur within surgical scars, generally from prior gynecologic operations.
- Cervical disease can occur in association with cervical trauma, typically cone biopsy or electrocautery.
- Vulvar disease can be seen at the site of an episiotomy scar.
- Abdominal wall endometriosis may occur after pelvic surgery, whereas some lesions, such as those of the umbilicus

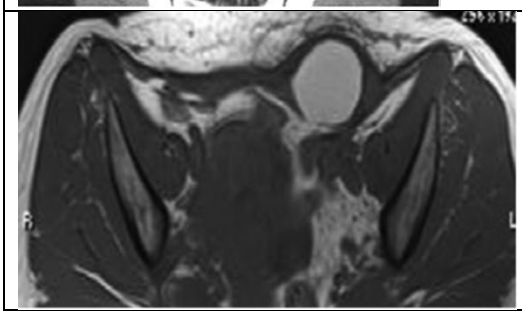


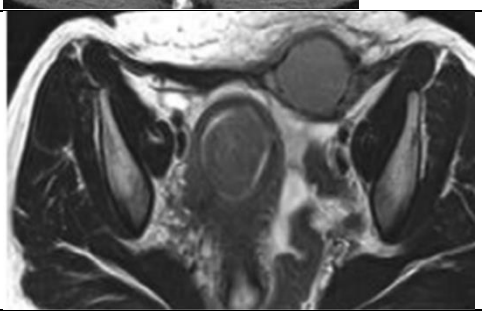
5) Abdominal and Pelvic Wall Scars

- Anterior abdominal or pelvic wall endometriosis may be nonspecific, but it typically appears as a solid soft-tissue mass directly associated with an area of surgical scarring
- NCCT: hyperattenuating compared with muscle.
- CECT: Mild to moderate enhancement







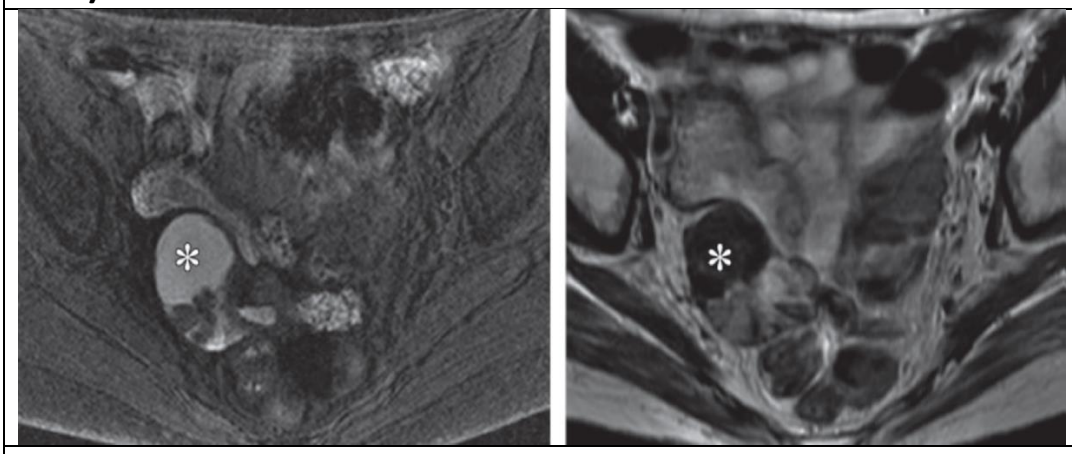


e)Endometriosis associated Malignancy

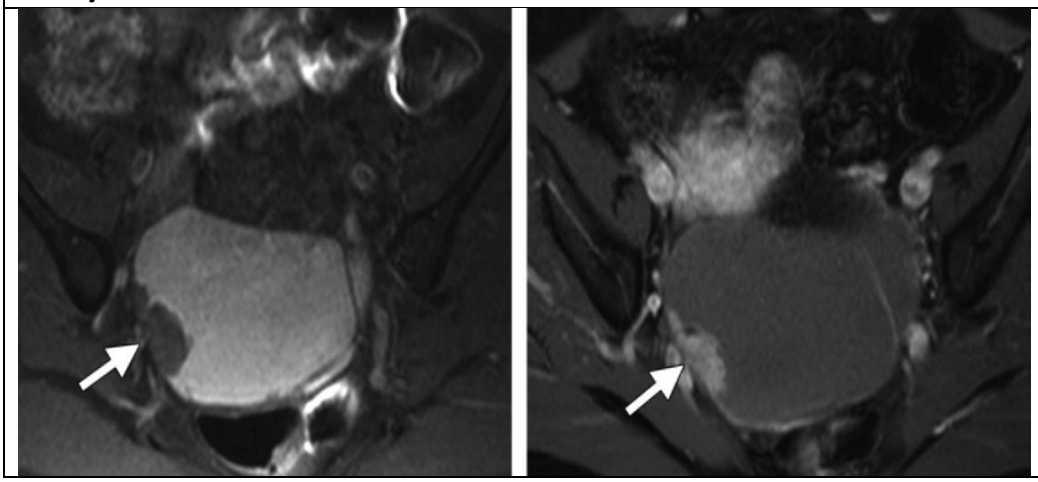
Diagnostic Criteria for Malignancy in Ovarian and Extraovarian Endometriosis

Malignancy in ovarian endometriosis
Endometrioma with an enhancing mural nodule or nodules on contrast-enhanced MR images
Endometrioma with increasing size on MR images
Endometrioma with loss of shading on T2-weighted MR images
Malignancy in extraovarian endometriosis
Solid mass or masses in the cul-de-sac, pelvic floor or ligaments, rectum, vagina or posthysterectomy vaginal vault, bladder, postpartum surgical scar, or nerve root seen on MR images
Intermediate signal intensity of the mass on T1- and T2-weighted images
Enhancement of the mass on contrast-enhanced MR images
Restricted diffusion in the mass on diffusion-weighted images and ADC maps
Lymphadenopathy
Endometriosis identified at MR imaging or surgery; or, in the absence of known endometriosis, a history of gynecologic surgery (eg, hysterectomy, cesarean section, episiotomy)

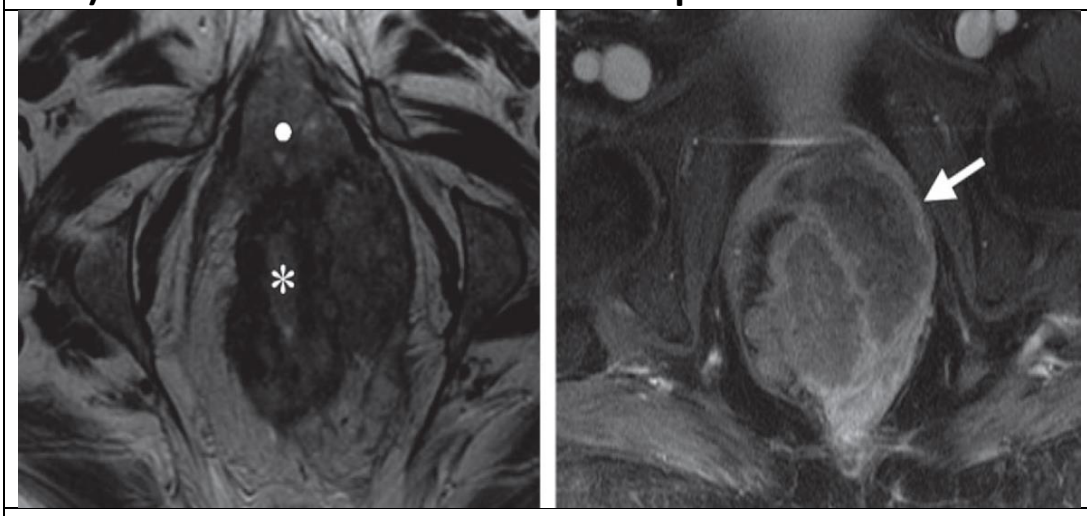
1) Endometrioid Carcinoma



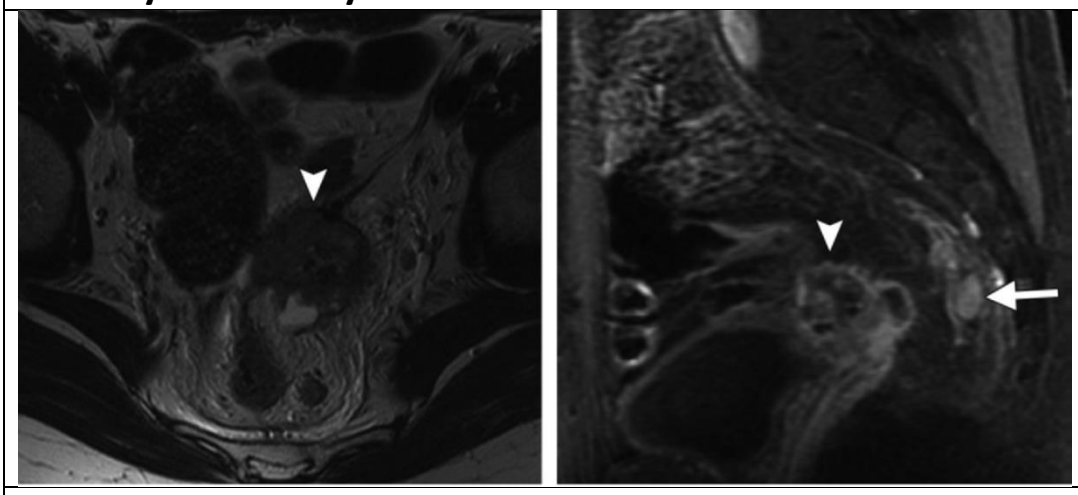
2) Clear Cell Carcinoma



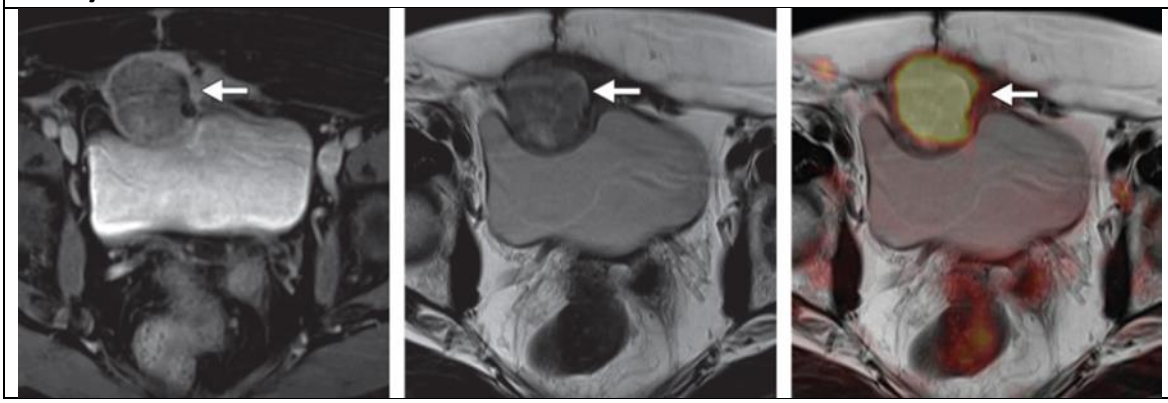
3) Endometrioid carcinoma of the pelvic floor



4) Endometrioid Carcinoma At Vaginal Vault Post Hysterectomy



5) Endometrioid adenocarcinoma in a cesarean section scar



Female Infertility

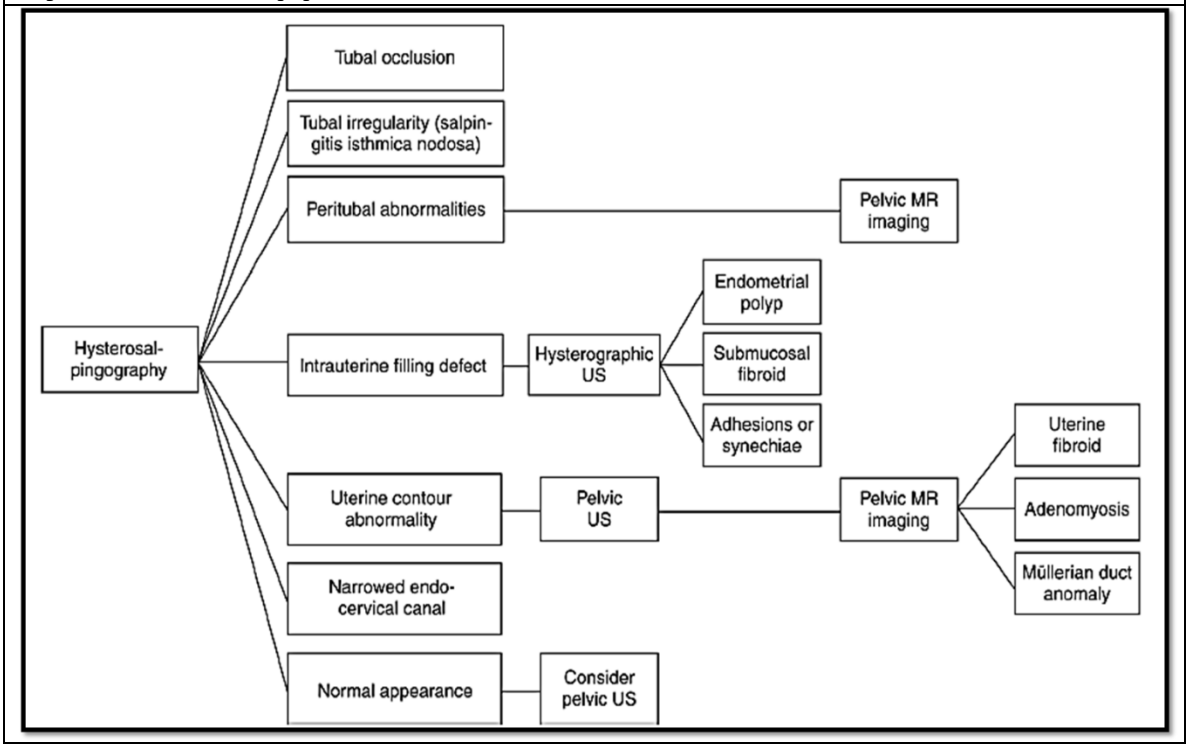
1ry Infertility is defined as 1 year of unprotected intercourse that does not result in pregnancy.

Imaging plays a crucial role in Diagnostic work-up & Treatment planning for female infertility.

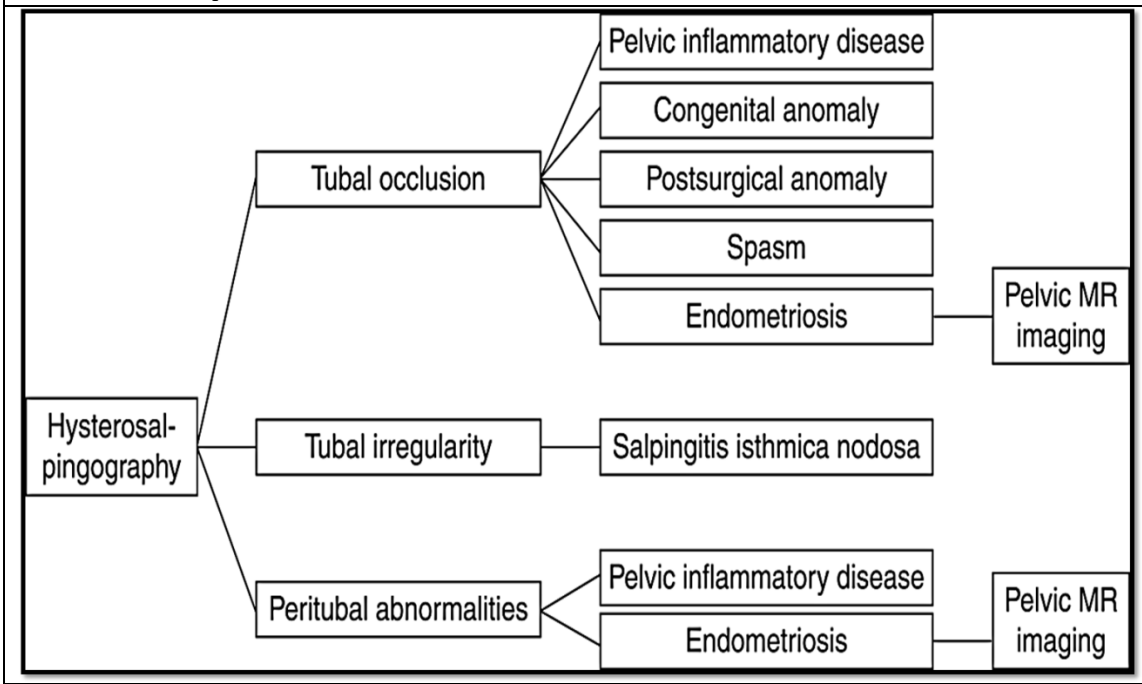
Imaging Modality

HSG
Pelvic US / TVUS
Pelvic MRI
MRI Pituitary

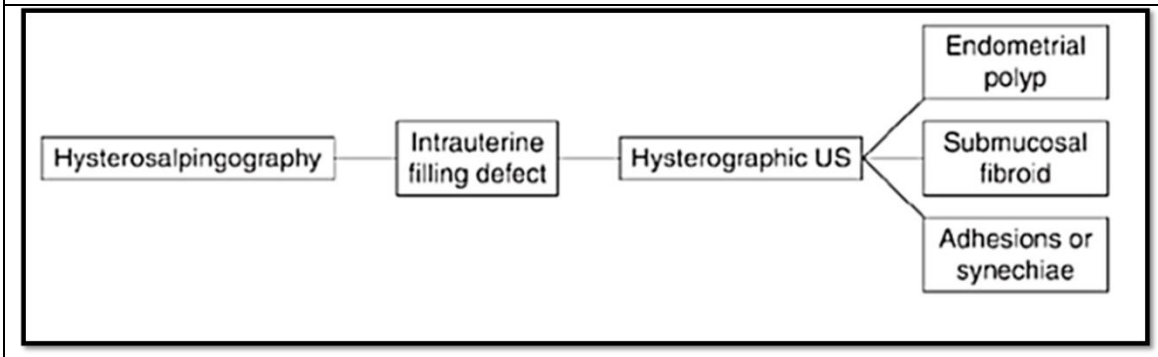
Systematic Approach

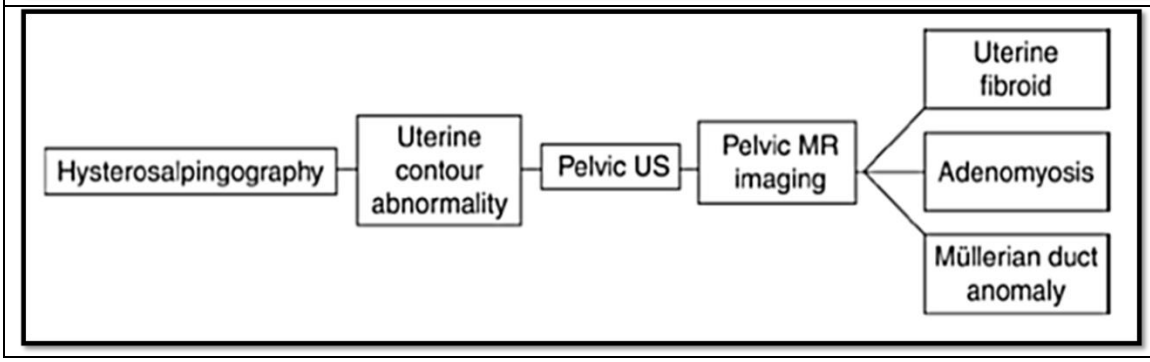


I. Fallopian Tube causes



II. Uterine Causes





III. Cervical Causes

Cervical Stenosis:

- 10% of causes of female infertility.
- 1ry or 2ry to:
- Infection
- Trauma / Hematoma
- Masses: cervical polyps, fibroids, and neoplasms
- HSG:
- Narrowing of the endocervical canal (normal diameter, 0.5–3.0 cm)
- Failure of cannulation of cervix during HSG

IV. Ovarian Causes

HSG => Normal => Pelvic US & MRI

Primary Ovarian Causes:

- Nonfunctional Ovaries.
- Premature Ovarian Failure
- Absence Of Ovaries (Gonadal Dysgenesis).

Secondary Ovarian Causes:

- Polycystic ovary syndrome
- Endometriosis.
- Ovarian cancer.

V. Pituitary Adenoma

- Prolactin-producing hypophyseal adenoma (prolactinoma) is the most common functional pituitary adenoma.
- Its prevalence peaks in women between 20 and 30 years of age.
- Hyperprolactinemia can be a cause of infertility and is associated with diminished gonadotropin secretion, secondary amenorrhea, and galactorrhea.
- MR imaging is the only imaging technique that can depict a pituitary microadenoma (1 cm).
- T1: lower signal intensity than the normal pituitary gland on T1 WI.
- Convex outline of the pituitary gland
- Deviation of the pituitary stalk to the contraleral side.
- In dynamic study: the normal pituitary gland and stalk show strong enhancement in the early phase of dynamic imaging, whereas microadenomas show relatively weak enhancement

1ry Amenorrhea

Primary amenorrhea is defined as

- No menarche by 16 years of age
- No thelarche nor adrenarche by 14 years of age
- No menarche more than 3 years after adrenarche and thelarche.

❖Causes of 1ry Amenorrhea:

A. Female anatomic anomalies

- Uterine Hypoplasia and Agenesis
  - Mayer-Rokitansky-Küster- Hauser
- Cervical stenosis
- Distal vaginal stenosis
- Transverse vaginal septum
- Imperforate Hymen

B. Congenital disorders of sexual differentiation

- Testicular Feminization
- Turner Syndrome
- Ambiguous Genitalia

C. Ovarian failure or dysfunction

- Polycystic ovary syndrome
- Resistant ovary syndrome
- Premature ovarian failure

D. **Hypothalamic or pituitary or endocrine causes:**

- Hyperprolactinaemia: the commonest pituitary cause of amenorrhoea; Pituitary adenomas
- Weight-related amenorrhoea
- Chronic illness
- Hypothalamus lesions (craniopharyngiomas ,germinomas, gliomas, dermoid cysts)
- Empty sella syndrome

E. Other Endocrine Gland Disorders

- Thyroid
  - Hypothyroidism
  - Hyperthyroidism
- Adrenal
  - Congenital adrenal hyperplasia
  - Cushing syndrome

Precocious Puberty

- **2ry Sexual characters <9y in boys and <8y in girls**

I) Central = True Precocious Puberty:

=> MRI Brain => Hypothalamic - Pitutary axis:

- Idiopathic Central PP.
- CNS Tumors: Hypothalamic - Pitutary Lesions (Sellar/Suprasellar)
  - Hamartoma
  - Hypothalamic/Chiasmatic glioma (NF-1)
  - Germinoma
  - Craniophangioma
  - Arachnoid cyst - Empty sella.
- CNS Injury:
  - Trauma - Infection - Radiation
  - Hypoxic ischemic encephalopathy (HIE)
  - Hydrocephalus

II) Peripheral = Pseudo Precocious Puberty:

A) Adrenal cortex lesions:

- Adrenal cortical neoplasms (ACN)
- Adrenal cortical hyperplasia.
- Syndromes: Li-Fraumeni cancer syndrome, Beckwith-Wiedemann syndrome, hemihypertrophy, Carney complex, MEN-1, and NF-1.

B) Ovary :

- McCune-Albright syndrome (Polystotic FD+PP+cafeaulait patches)
- Functional Follicular cyst
- Sex cord stromal tumors (Juvenile GCT)

C) Testis:

- Adrenal rests
- Sex-cord-stromal tumors (Sertoli - Leydig - Juvenile GCT - Undifferentiated)

Acute Pelvic Pain

1. **Pregnancy related**
   - Spontaneous abortion
     - Threatened
     - Complete
     - Incomplete
     - Septic
   - Ectopic pregnancy

2. **Gynecologic: infectious**
   - Endometritis
   - PID/salpingitis
   - TOA

3. **Gynecologic: noninfectious**
   - Dysmenorrhea
   - Uterine fibroids
   - Endometriosis
   - Mittelschmerz (midcycle ovulatory pain)
   - Ovarian cysts
     - Rupture
     - Hemorrhage
     - Torsion
   - Ovarian cancer/tumor
   - Ovarian hyperstimulation syndrome

4. **Nongynecologic**
   - Gastrointestinal
     - Appendicitis
     - Gastroenteritis
     - Diverticulitis
     - Inflammatory bowel disease
     - Irritable bowel syndrome
     - Bowel obstruction
     - Mesenteric lymphadenitis
     - Constipation
     - Abdominopelvic adhesions
   - Urinary tract
     - Lower urinary tract infection/cystitis
     - Interstitial cystitis
     - Pyelonephritis
     - Nephrolithiasis
   - Musculoskeletal
     - Strained tendons/muscles
     - Joint infection/inflammation
     - Hernia
   - Other
     - Aortic aneurysm
     - Aortic dissection
     - Porphyria

MRI Evaluation of Acute Abdominal Pain during Pregnancy

- **GIT**
  - Acute Appendicitis
  - Inflammatory bowel disease
  - Diverticulitis
  - Bowel obstruction
- **Hepatobiliary Causes**
  - Cholelithiasis
  - Choledocholithiasis
  - Acute cholecystitis
  - Pancreatitis
  - Hepatitis.
- **Pregnancy related Hepatobiliary causes**
  - HELLP (hemolysis, elevated liver enzyme levels, and low platelet count) syndrome
  - acute fatty liver of pregnancy
- **GU**
  - Physiologic Hydronephrosis
  - Obstructive hydronephrosis
- **Vascular causes**
  - Venous Thromboembolic Disease
  - Gonadal vein dilatation.
- **Gynecologic Causes**
  - Leiomyoma
  - Adnexal masses
  - Endometriosis
  - Pelvic inflammatory disease
  - Ovarian torsion
  - Ovarian edema.

MR Imaging Findings of Various Diagnoses in the Emergency Setting

Indication	MR Imaging Findings
Bowel disease	
Appendicitis	Elevated T2 signal in periappendiceal fat and dilated appendix, thickened cecum wall
Diverticulitis	Elevated T2 signal in pericolonic fat with associated diverticula, wall thickening of affected colon
Pancreatic disease	
Acute pancreatitis	Elevated T2 signal within and surrounding the pancreas
Hemorrhagic pancreatitis	Elevated signal intensity on precontrast fat-saturated T1-weighted images
Pancreatic necrosis	Decreased or absent enhancement of pancreatic parenchyma
Chronic pancreatitis	Decreased signal intensity on precontrast T1-weighted images, dilatation of main pancreatic duct and side branches, delayed enhancement of the pancreas
Pseudocyst	Complex cyst with internal elevated T1 signal (from blood products) that dissects along fascial planes
Biliary disease	
Acute cholecystitis	Elevated T2 signal within and around the gallbladder; marked abnormal enhancement of the gallbladder wall, with associated abnormal enhancement of the adjacent hepatic parenchyma due to inflammation
Choledocholithiasis	Stones appear as rounded signal voids surrounded by fluid
Renal disease	
Urinary obstruction/ renal stones	Dilated renal collecting system with elevated T2 signal surrounding the urothelial system and kidney, related to edema; renal stones (if visible) manifest as a dark signal void
Renal abscess	Complex fluid collection with thickened, hypointense rim on T2-weighted images; abnormal renal parenchymal signal intensity with elevated perinephric signal intensity on T2-weighted images

Gynecologic disease	
Torsion	Enlarged ovary with elevated T2 signal within the ovarian stroma, enlarged follicles seen along the periphery of the twisted ovary
Endometrioma	Uniform, markedly elevated T1 signal intensity within an ovarian cyst, with or without "shading," on T2-weighted images; endometrial implants manifest as foci of elevated T1 signal along serosal surfaces
Hemorrhagic cyst	Heterogeneously elevated T1 signal, although less than that seen with endometrioma; fluid with elevated T1 signal (representing hemorrhage) in the pelvis if cyst has ruptured
Tubo-ovarian abscess	Complex fluid collection within the adnexa with surrounding elevated T2 signal
Pregnancy	
Placental abruption	Increased T1 signal within the uterus at the site of bleeding
Placenta previa	Abnormal position of the placenta infringing on the cervical os

Postpartum Hemorrhage

Postpartum hemorrhage is an obstetric emergency that may occur after vaginal delivery or cesarean section.

Blood loss > 500 mL after vaginal delivery
Blood loss > 1000 mL after cesarean section

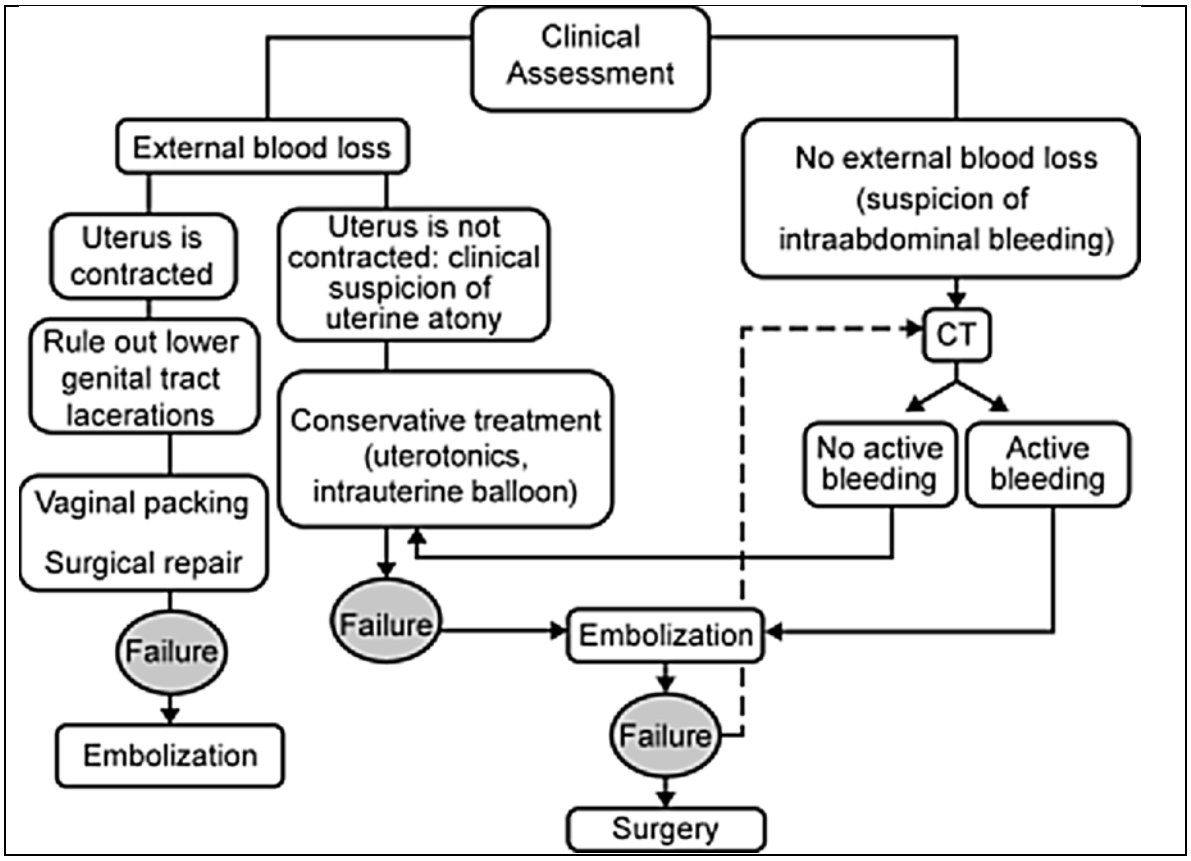
1ry = first 24 hours after delivery.
2ry = between 24 hours and 6 weeks after delivery

Primary postpartum hemorrhage

- Uterine atony
- Trauma to the lower portion of the genital tract
- Bladder flap hematoma
- Uterine rupture
- Uterine inversion
- Retained placental fragments or products of conception
- Abnormal placentation*
- Coagulopathies (acquired or congenital)

Secondary postpartum hemorrhage

- Retained placental fragments or products of conception
- Endometritis
- Coagulopathies (acquired or congenital)
- Trauma to the lower portion of the genital tract (delayed rupture
- Placental abnormalities (managed conservatively)


Clinical Assessment
External blood loss
No external blood loss (suspicion of intraabdominal bleeding)
Uterus is contracted
Uterus is not contracted: clinical suspicion of uterine atony
CT
Rule out lower genital tract lacerations
Conservative treatment (uterotonics, intrauterine balloon)
No active bleeding
Active bleeding
Vaginal packing
Surgical repair
Failure
Failure
Embolization
Embolization
Failure
Surgery